

# GIS Special Studies and Pilot Projects for Iowa DOT

FINAL REPORT

Sponsored by the Iowa Department of Transportation

January 1997



IOWA STATE UNIVERSITY



The opinions, findings, and conclusions expressed in this publication are those of the authors and not necessarily those of the Iowa Department of Transportation.

CTRE's mission is to develop and implement innovative methods, materials, and technologies for improving transportation efficiency, safety, and reliability while improving the learning environment of students, faculty, and staff in transportation-related fields.

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FINAL REPORT

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# Evaluation of ArcView 3.0a CAD Reader Extension

## Objective

The objective of this task is to evaluate ArcView 3.0a, specifically its CAD Reader extension, for potential use with Iowa Department of Transportation (DOT) MicroStation and Modular GIS Environment (MGE) data.

## Background

The Iowa DOT currently utilizes MicroStation to maintain its cartographic data. MicroStation is also used in conjunction with the DOT's maintenance GIS software, MGE. If potential users of these data do not possess MicroStation, MGE, or *Intergraph's* GeoMedia software, the data must be converted to another format, potentially resulting in data redundancy and/or loss. However, *ESRI's* ArcView product (a commonly used desktop mapping software) has the ability to read CAD files, included MicroStation files, in their native format.

ArcView's CAD Reader extension allows a CAD drawing to be treated as a feature data source in ArcView. An attribute table, consisting of entity properties such as color, linetype, elevation, thickness, is associated with each CAD Drawing theme. A theme's attribute table may also store AutoCAD block attributes, MicroStation tags, and MicroStation database linkages. Therefore, ArcView users may be able to both view DOT MicroStation data (in their native format) and, if database linkages exist on the MicroStation entities, connect to the appropriate database table(s).

## Methodology

Several criteria were used to evaluate ArcView's ability to work with Iowa DOT MicroStation data. These evaluation criteria follow:

- Ability to correctly and accurately represent MicroStation entities and control MicroStation levels.
- Ability to correctly position MicroStation entities on the face of the earth, including overlaying other non-DOT data sets.
- Ability to connect to database attribute tables (for MicroStation entities with database linkages only).

These evaluation criteria may possess differing levels of importance depending on the desired use of the MicroStation data within ArcView.

## Evaluation

### *Correct and Accurate Representation of MicroStation Entities*

ArcView documentation states that when a CAD drawing theme is added to an ArcView view, a default legend is created which matches the colors used in the source drawing file. For the most part, the colors of MicroStation entities in ArcView appear to be fairly consistent with the original colors; however, other entity characteristics, such as line thickness, are not maintained by ArcView. (Some of these characteristics, including

color, can be edited using the ArcView Legend Editor.) In addition, when working with a DOT highway and transportation map, ArcView is unable to display the MicroStation text elements. This includes text within MicroStation cells, specifically, US, State, and County road symbols.

When a CAD drawing is added as an ArcView theme, all visible drawing levels/layers are selected. These levels can be made visible, or not visible, by defining the theme's properties. The theme's properties can also be utilized to filter which MicroStation entities to include in the theme. Since ArcView organizes data in themes (and MicroStation data are often organized by levels), it may be necessary to create multiple themes from a single drawing source. For example, if each MicroStation level represents a unique feature type (e.g. roadway centerlines, rivers, etc.), a theme should be created for each level. Unique MGE features should also occupy a single theme. If the same MGE feature exists on several levels, a query of the entities' database linkages (discussed later) can be utilized to select the appropriate entities.

### ***Correct Positioning of MicroStation Entities***

An important consideration, with respect to ArcView's functionality, is its ability to work with (overlay) both DOT and non-DOT data. Since DOT MicroStation entities are referenced to a projected coordinate system, ArcView must be able to correctly position DOT data on the earth's surface. A CAD drawing theme must be added to an ArcView view with the appropriate coordinate system defined. In addition, ArcView supports coordinate transformations to ensure that CAD drawing themes register properly. Both one-point transformations (the CAD drawing theme is shifted to a new location in geographic space) and a two-point transformation (a transformation matrix is used to apply a coordinate offset, scale, and rotation uniformly to all drawing source coordinates) are supported.

Adding a MicroStation highway and transportation map to a view defined by the DOT's projection parameters yields an incorrect representation of the MicroStation file. Entities are rotated approximately 30° west of north, and the map scale and projected coordinate values are incorrect. A coordinate transformation from MicroStation master unit coordinates to projected coordinates also provides unsuccessful results. If the aforementioned coordinate transformation is applied to a view with no projection, DOT MicroStation themes appear to possess the correct orientation, scale, and projected coordinate values, but the theme has no geographic reference. DOT data sets (with a common projection) appear correctly positioned with respect to each other, but data from other sources, such as the Iowa Department of Natural Resource, will not overlay properly. Therefore, it is unlikely that DOT MicroStation data and non-DOT data (describing the same area) can be effectively used together in ArcView.

### ***Database Linkages on MicroStation Entities***

A final evaluation criterion is ArcView's ability to utilize database linkages on MicroStation entities. Of primary interest are the database linkages established by MGE. Two attribute fields are added for each database linkage. One field stores the Mslink value while the other field stores the Mscatalog information, which, by default, is not

visible. A simple example is a MicroStation entity with one MGE feature and attribute linkage. Four database-related attributes, two Mslink-MSCtlg pairs, will exist in the theme's attribute table. The first Mslink represents the mslink value of the MGE feature in the MGE feature table. The associated MSCtlg value is the entity number (i.e. feature table) in the MGE mscatalog table. The second Mslink is the mslink value of the appropriate record in the database attribute table. Its associated MSCtlg value is the entity number (i.e. attribute table) in Mscatalog table.

Knowledge of the MGE mscatalog table is essential for users to include the correct MicroStation entities in a theme as well as access the appropriate database tables. ArcView users must know which feature(s) an entity represents and which attribute table(s) describe the entity. Users can connect to a database server, perform queries, and retrieve records by using ArcView's SQL connection feature, which is based on Microsoft's ODBC (Open DataBase Connectivity). Records residing in the database server can be joined to records in the theme's attribute table by using mslink values. If users can not connect to the database server, the appropriate attribute tables can be exported and then imported into ArcView. A similar join relationship can be established. These join relationships can be used to query graphic elements and create thematic maps based on attributes stored in the database server. However, working with MicroStation entities with database linkages may become increasingly more complicated when the entities have multiple feature and attribute linkages.

### **Conclusions**

In general, ArcView's CAD Reader extension is a nice tool to view Iowa DOT MicroStation data in their native format. Its ability to read database linkages on MicroStation entities and connect to database servers facilitates working with the DOT's MGE data. In addition, DOT data may be distributed to ArcView users without requiring translation; only a description of the mscatalog table and exported attribute tables may be required. However, ArcView's functionality, with respect to working with DOT data, is limited by its apparent inability to position the data correctly on a projected plane (coordinate system).

# Updating Base Records with IPMP Data

## Objective

The objective of this task is to develop procedures to provide pavement condition data to the Iowa Department of Transportation's (DOT) Office of Transportation Data for use in the Base Record Inventory System.

## Background

As part of the Iowa Pavement Management Program (IPMP), pavement condition (distress) data are collected on Federal aid eligible, non-National Highway System roadways throughout the State. Condition data are collected on two year cycles (beginning in 1996) for the entire state system and local systems in Regional Planning Affiliations (RPAs) 2, 3, 4, 6, 7, 8, 9, 12, 14, 15, 16, 18 and the Des Moines and Cedar Rapids Metropolitan Planning Organizations (MPOs).

In 1995, roadway inventory and history data were collected from all Iowa jurisdictions (including cities with 5,000 or more population and all counties and are now updated annually.

The Office of Transportation Data may potentially use the pavement condition data, as well as data from the history surveys, to update older data stored in the Department's Base Record Inventory System. However, those participating in the IPMP project should first approve using the data for these purposes.

## Methodology

### *Update Road Names*

IPMP uses a GIS database (Intergraph's MGE accessing an Oracle database) to store and manage pavement condition, inventory, and history data. Pavement condition data are collected by ROADWARE Corporation, inventory data are provided by the Iowa DOT from the Base Record Inventory System, and history data are provided by local governmental agencies. Each of these data sets are referenced in a different manner; therefore, dynamic segmentation is used to integrate these various data sets.

In order to utilize dynamic segmentation, several linear referenced highway networks were created from DOT cartography and base record data. As these networks were developed, an additional attribute, an updated road name, was added. This attribute was only updated with a new road name from the history data when the existing base record road name was "No Name", "0000", or obviously incorrect; otherwise, the field was populated with the existing base record road name. Querying the database for records where the road names are different yields the base records that Transportation Data must update. Transportation Data can either be provided with an ASCII file containing only these records (with the appropriate base record controls and updated road names) or all records (with the same attributes).

### ***Update Condition Data***

Pavement condition data are collected continuously along the roadway and provided as 100 meter long sections. Geographic coordinates (longitude/latitude) note the beginning and ending locations of the sections. For the IPMP project, dynamic segmentation is used to update the history records (pavement management sections) with the distress data occurring along the section. Software tools are used to automatically sum, or average, distresses along the history section. Distress segments overlapping two history sections are, by default, included in the distress calculations for both history sections – in effect, double counting the distresses. Since the distress segments are considerably shorter than the pavement history sections, this double counting of the data is not a significant concern for pavement management. However, with additional effort, these records can be eliminated from consideration.

Transportation Data is interested in receiving raw distress data, and performing calculations in-house, to update base record pavement condition data. Through use of dynamic segmentation, distress records and base record segments are overlaid, and the distress records are updated with the control attributes from the base record segment they fall within. If a distress record overlaps two base record segments, it is not updated. Distress data from these sections will not be provided to Transportation Data and will not be included in their calculations, resulting in a loss of some of the raw distress data.

## DOQQ / DRG Registering Process

Drg\_view.mbx – MapBasic conversion program found on CTRE's G:/student/manu  
-can also be found on internet at [www.gisnet.com/gis/mapinfo/files1.htm](http://www.gisnet.com/gis/mapinfo/files1.htm)  
-produces a pull-down menu in MapInfo to automatically register DRGs

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-produces a pull-down menu in MapInfo to automatically register DOQQs

Process for using .mbx programs:

Open MapInfo

File – Run MapBasic Program

(open .mbx file and pull-down menu is automatically created)

If these programs cannot be found or work improperly, registering can be accomplished manually.

### Manually Registering DOQQs

A DOQQ consists of two files: an image file and a header file. An image file's extension ends with a 'c', whereas a header file's extension ends with an 'h'.

In order for MapInfo to recognize the image file, it must be renamed with a '.jpg' extension. So locate the image file and rename it with a .jpg extension.

Each image has four reference points used to locate the image in a graphic environment: one each in the SW, NW, NE, and SE corner of the image. Each of these points can be described using pixels and/or earth coordinates. The pixel and earth coordinates for an image can be found in the corresponding header file. The header file can be viewed in DOS with the EDIT program. Make sure to write down these coordinates so they can be entered easily into MapInfo when it asks for them

The header file is broken up into four records – one on each of four lines.

Record 1 (line 1) contains the earth coordinates for the reference points

Record 3 (line 12) contains the pixel coordinates for the reference points

In record 1 starting at about column 208, earth coordinates (in exponential form) for the reference points are listed in (x,y) order for reference points in the order SW, NW, NE, SE.

In record 3 starting at about column 724, pixel coordinates (in integer form) for the reference points are listed in (y,x) order for reference points in the order SW, NW, NE, SE.

Enter these values during the registering process in MapInfo as follows:

Open MapInfo

Open table

Files of type: Raster Image

(find and open .jpg file)

Register

Projection...

-Category -Universal Transverse Mercator (NAD 83) -UTM Zone 15

Units...

-Meters

(click on image)

(enter pixel and earth coordinates for one of the corners)

(repeat until all four corners have been entered)

### **Manually Registering DRGs**

After choosing a specific block to look at, open the associated .fgd file (located in the Metadata subdirectory) in a text editor. This file contains lots of background information on the digital raster graphic. The information needed from this file is very near the bottom of the file. Read off the following information:

Row Count (this is the number of vertical pixels on the drg)

Column Count (this is the number of horizontal pixels on the drg)

UTM Zone Number

Abcissa Resolution (this is the number of earth meters contained in one pixel)

Ordinate Resolution

Now open the associated .tfw file (located in the Data subdirectory) for the chosen block in a text editor. There will be six lines of data in this file. The fifth line of data is the earth x-coordinate of the upper left corner of the drg. The sixth line of data is the earth y-coordinate of the upper left corner of the drg. This is all the information needed to register the image in MapInfo. Before actually opening MapInfo, it is helpful to do some calculations. Drawing a model showing the corners of the drg and the pixel and earth coordinates for each corner is also very helpful.

During the registering process in MapInfo, the earth coordinates and pixel coordinates for the four corners of the drg image will need to be known.

For pixel coordinates:

The upper left corner of the image has coordinates (1,1)

The x-coordinate at the right edge of the image equals the Column Count number minus one

The y-coordinate at the bottom of the image equals the Row Count number minus one

(note: for pixels, y-coordinates **increase** downward)

For earth coordinates:

The upper left corner of the image has earth coordinates found in the .tfw file

The x-coordinate at the right edge of the image equals the Column Count number multiplied by the Abcissa Resolution, then added to the earth x-coordinate of the upper left corner

The y-coordinate at the bottom of the image equals the Row Count number multiplied by the Ordinate Resolution, then added to the earth y-coordinate of the upper left corner

(note: for earth coordinates, y-coordinates **decrease** downward)

Enter these values during the registering process in MapInfo as follows:

Open MapInfo

Open table

Files of type: Raster Image

(find and open .tif file (in Data subdirectory), then save as a .tab file)

Register

Projection...

-Category -Universal Transverse Mercator (NAD 27-US) -UTM Zone 15

Units...

-Meters

(click on image)

(enter pixel and earth coordinates for one of the corners)

(repeat until all four corners have been entered)

## GIS Data & Map Related Web Sites

The following is a list of GIS related web sites which contain possible data available for downloading and representative maps. These may be useful in coming up with a nationwide database or by updating the current Iowa Transportation data. Note that most of these sites have extra links that would be beneficial in obtaining more information and data on transportation related topics.

### List of State Departments of Transportation

#### Alabama Department of Transportation

- <http://www.dot.state.al.us/Bureau/Equipment/maps.HTM> - General highway county maps, highway maps of the state, highway traffic flow maps, and state and county outline maps available for purchase by writing or downloading an order form from the DOT
- Data is available with the maps but you may not download the information directly from the homepage  
<http://www.dot.state.al.us/>

#### Alaska Department of Transportation and Public Facilities

- No maps or data available for downloading yet  
<http://www.dot.state.ak.us/>

#### Arizona Department of Transportation

- <http://www.dot.state.az.us/ROADS/cae/standard.html> – Zip files are available for downloading CADD symbols used by the DOT  
<http://www.dot.state.az.us/>

#### Arkansas State Highway and Transportation Department

- <http://www.ahtd.state.ar.us/maps.htm> - The State Highway Map or Tourist Map is available free of charge. Individual county, city and other maps are available for purchase.  
<http://www.ahtd.state.ar.us/>

#### California Department of Transportation

- [http://www.maxwell.com/caltrans/la/la\\_transnet.html](http://www.maxwell.com/caltrans/la/la_transnet.html) – Current real time traffic maps for Los Angeles, Orange County, and San Diego
- <http://gocalif.ca.gov/maps/> - Maps available for downloading in PDF format free of charge from the Department of Tourism  
<http://www.dot.ca.gov/>

#### Colorado Department of Transportation

- <http://www.dot.state.co.us/public/index.htm> – Maps are available for viewing numerous cities and areas  
<http://www.dot.state.co.us/>

#### Connecticut Department of Transportation

- <http://magic.lib.uconn.edu/http/Connecticut.html> - MAGIC Map and Geographic Information Center
- State, county, town, and quad level data available for the state of Connecticut
- Zip files available in Arc/Info and MapInfo format  
<http://www.state.ct.us/dot/>

#### Delaware Department of Transportation

- No data or maps available on web site  
<http://www.state.de.us/deldot.index.htm>

#### Florida Department of Transportation

- <http://www.dot.state.fl.us/publicat/manuals/pub-emap.htm> – County maps available for a certain price
- <http://www.dot.state.fl.us/publicat/manuals/pub-soft.htm> – Software available for downloading
- <http://www.dot.state.fl.us/business/ecso/files/files.htm> – Florida DOT Cadd files available for downloading by the use of an ftp site  
<http://www.dot.state.fl.us/>

#### Georgia Department of Transportation

- <http://www.dot.state.ga.us/homeoffs/construction/ConMaps/conmap.html> – Traveler information construction status maps available for viewing only
- No files available for downloading data or maps  
<http://www.dot.state.ga.us/>

#### Hawaii Department of Transportation

- No information or maps available for downloading  
<http://www.hawaii.gov/dot/>

#### Idaho Transportation Department

- No information or maps available for downloading  
<http://www.state.id.us/itd/itdhmpg.htm>

#### Illinois Department of Transportation

- No information or maps available for downloading  
<http://dot.state.il.us/>

#### Indiana Department of Transportation

- <http://www.ai.org/dot/city.htm> – Download city maps in pdf or jpg format  
<http://www.ai.org/dot/>

#### Iowa Department of Transportation

- No information or maps available for downloading  
<http://www.state.ia.us/government/dot/>

#### Kansas Department of Transportation

- <http://www.ink.org/public/kdot/maps/maps.html> – State, city, and county maps available for downloading in dgn format  
<http://www.ink.org/public/kdot/>

#### Kentucky Transportation Cabinet

- <http://www.kytc.state.ky.us/map.htm> - Highway maps of Kentucky's 120 counties, 435 incorporated cities, and various other map products are available for purchase from the Cabinet for Economic Development's Maps and Publications Office
- <http://ukcc.uky.edu/~maps/> - General County Highway Maps available for downloading over the web in gif format. Note the files have an ftp site
- <http://www.kytc.state.ky.us/files.htm> – Download bridge specification files in dgn format  
<http://www.ink.org/public/kdot/maps/maps.html>

#### Louisiana Department of Transportation and Development

- No maps or data is available for downloading  
<http://www.dotd.state.la.us/>

#### Maine Department of Transportation

- <http://www.state.me.us/mdot/planning/sysinven/maps.htm> – County and State maps available for viewing and purchasing  
<http://www.state.me.us/mdot/homepage.htm>

#### Maryland Department of Transportation

- [http://www.inform.umd.edu/UMS+State/MD\\_Resources/MDOT/docs/index.html](http://www.inform.umd.edu/UMS+State/MD_Resources/MDOT/docs/index.html) – Documents concerning the environment, state highway administration, and motor vehicle administration are available for downloading in pdf format
- [http://www.inform.umd.edu/UMS+State/MD\\_Resources/MDOT/sha/maplst/maprice.htm](http://www.inform.umd.edu/UMS+State/MD_Resources/MDOT/sha/maplst/maprice.htm) – Maryland State Highway Administration maps available for purchase  
[http://www.inform.umd.edu/UMS+State/MD\\_Resources/MDOT/](http://www.inform.umd.edu/UMS+State/MD_Resources/MDOT/)

#### Massachusetts Highway Department

- [http://www.magnet.state.ma.us/mgis/gis\\_toc.htm](http://www.magnet.state.ma.us/mgis/gis_toc.htm) - Massachusetts GIS Data and Maps
- Data and maps available on towns, quads, land use, wetlands, and hydrography
- Files are in ArcView format  
<http://www.magnet.state.ma.us/mhd/home.htm>

#### Michigan Department of Transportation

- <http://www.mdot.state.mi.us/maps/mapunit/pricelst.htm> – List of state, county, and city maps available for purchase
- <http://www.mdot.state.mi.us/planning/ADT.HTM> - Michigan 1996 Annual Average 24-hour Traffic Volume Maps
- This page contains maps showing 1996 Annual Average 24-Hour Traffic (AADT) Volumes for all state maintained roads

- No files are available for downloading, however Adobe Acrobat is needed to view the map
- Note this is just an example of how Michigan posts their AADT  
<http://www.mdot.state.mi.us/>

#### Minnesota Department of Transportation

- <http://www.dot.state.mn.us/guidebook/maps.html> – Documents available to the public, maps, manuals, etc. for purchase only  
<http://www.dot.state.mn.us/>

#### Mississippi Department of Transportation

- <http://www.maris.state.ms.us/htms/spdatao.htm> - Files are not necessarily ready to be downloaded, yet one can order the files by filling out a special form online
- The two available formats, Arc/Info export files and ArcView shape files, are those most frequently used in Mississippi State government  
<http://www.mslawyer2.com/statedept/transpor.html>

#### Missouri Department of Transportation

- No maps or information available to download  
<http://www.modot.state.mo.us/>

#### Montana Department of Transportation

- <ftp://ftp.mdt.mt.gov/caddstd/> - Current Cadd Standards available by <ftp://ftp.mdt.mt.gov/> ftp site  
<http://www.mdt.mt.gov/>

#### Nebraska Department of Roads

#### Nevada Department of Transportation

#### New Hampshire Department of Transportation

- No maps or information available to download  
<http://www.state.nh.us/>

#### New Jersey Department of Transportation

- <http://www.state.nj.us/transportation/gis/maps.htm> – Maps are in pdf format and require Adobe Acrobat for viewing
- <http://www.mapblast.com/> - Mapblast allows you to view any location in the United States!  
<http://www.state.nj.us/transportation/>

#### New Mexico Highway and Transportation Department

- No maps or information available to download  
<http://www.state.nm.us/state/htd.html>

#### New York State Department of Transportation

- <http://www.dot.state.ny.us/magis/magis.html> – MAGIS is the mapping and GIS section of New York
- Paper maps, digital maps, and metadata are available for purchase only  
<http://www.dot.state.ny.us/>

#### North Carolina Department of Transportation

- <http://www.doh.dot.state.nc.us/planning/gis/map/downloadmaps.html> – Digital county maps available to download in dgn format by an ftp site  
<http://www.dot.state.nc.us/>

#### North Dakota Department of Transportation

- No maps or information available to download  
<http://www.state.nd.us/dot/>

#### Ohio Department of Transportation

- <http://www.dot.state.oh.us/map1/> - Download Ohio cities, counties, and districts in dgn format
- <http://www.dot.state.oh.us/map1/ohiomap/index.htm> – Excellent color city and county maps available for presentations  
<http://www.dot.state.oh.us/>

#### Oklahoma Department of Transportation

- <http://seic.lse.okstate.edu/okgis.html> - Metadata for: Watershed Boundaries and Digital Elevation Model of Oklahoma Derived from 1:100,000-scale Digital Topographic Maps
- Variety of different maps that are accessible for downloading
- Files can be downloaded by use of an ftp site or Arcview  
<http://www.okladot.state.ok.us/>

#### Oregon Department of Transportation

- No maps or information available to download  
<http://www.odot.state.or.us/index.htm>

#### Pennsylvania Department of Transportation

- No maps or information available to download  
[http://www.hbg.psu.edu/psdc/affiliates/state\\_agency/Pennsylvania-Department-of-Transportation.html](http://www.hbg.psu.edu/psdc/affiliates/state_agency/Pennsylvania-Department-of-Transportation.html)

#### Rhode Island Department of Transportation

- <http://www.edc.uri.edu/rreapage/gisdata/> - Rhode Island Geographic Information Systems Data
- A variety of GIS data is available, but the user must fill out a license agreement
- Must fill out agreement to obtain format of files  
<http://www.dot.state.ri.us/>

#### South Carolina Department of Transportation

- No maps or information available to download

<http://www.dot.state.sc.us/default.htm>

#### South Dakota Department of Transportation

- No maps or information available to download  
<http://www.state.sd.us/state/executive/dot/dot.html>

#### Tennessee Department of Transportation

- No maps or information available to download  
<http://www.state.tn.us/transport/index.html>

#### Texas Department of Transportation

- <http://www.dot.state.tx.us/insdot/geodist/geodist.htm> – Districts in Texas which give a variety of information such as population, lane miles, and daily vehicle miles
- These files can not be downloaded but may be useful for your files  
<http://www.dot.state.tx.us/txdot.htm>

#### Utah Department of Transportation

- [http://www.sr.ex.state.ut.us/html/site\\_documents.htm](http://www.sr.ex.state.ut.us/html/site_documents.htm) – Program development, traffic and other road statistics that can be downloaded in pdf format  
<http://www.sr.ex.state.ut.us/>

#### Vermont Agency of Transportation

- <http://www.aot.state.vt.us/cadd/cadd.htm> – CADD files available to download from the DOT
- <http://www.aot.state.vt.us/vaotgis/vaotgis.asp> – GIS Maps available to download only if you have Geomedia software  
<http://www.aot.state.vt.us/>

#### Virginia Department of Transportation

- <http://www.vdot.state.va.us/maps/maps.html> – Maps of cities, routes, and highways for the state in pdf format
- <http://www.vdot.state.va.us/info/publications.html> – More maps and publications available either to download in pdf format or to purchase  
<http://www.vdot.state.va.us/>

#### Washington State Department of Transportation

- [http://www.wsdot.wa.gov/ppsc/TDO/tdo\\_hp.htm](http://www.wsdot.wa.gov/ppsc/TDO/tdo_hp.htm) – The Transportation Data Office contains specific reports on accident and travel data, travel analysis, WIM, and many more applications
- Files are not available for downloading  
<http://www.wsdot.wa.gov/>

#### West Virginia Department of Transportation

- <http://www.state.wv.us/wvdot/wvdotctr/drive/maps/ordermaps.htm> – Order the West Virginia highway map for purchase
- <http://www.state.wv.us/wvdot/wvdotctr/doh/division/se/caddstds/downfile.htm> – Zipped CADD files available for downloading

<http://www.state.wv.us/wvdot/wvtrans.htm>

#### Wisconsin Department of Transportation

- No maps or information available to download  
<http://www.dot.state.wi.us/>

#### Wyoming Department of Transportation

- No maps or information available to download  
<http://wydotweb.state.wy.us/>

### **More Sites Containing Maps or Data**

#### U.S. Census Bureau 1990 Office Statistics

- List of numerous population data on each state, i.e. Race, Language Spoken, etc.
- Files available in HTML, Tab-delimited, or CODATA format  
<http://venus.census.gov/cdrom/lookup/>

#### Available Digital Geo-spatial Data and Metadata – The National Park Service

- Data and metadata available for certain states
- Types of data include park boundaries, access, abandoned right-of-ways, roads, county boundaries, elevation, floodplain, hydrology, etc.
- Files are compatible with any GIS software  
[http://hans.nrrc.ncsu.edu/npsgis/available\\_data.html](http://hans.nrrc.ncsu.edu/npsgis/available_data.html)

#### The Center for Global & Regional Environmental Research – University of Iowa

- List of various sites that have information available to download
- Geo-spatial, weather, and USGS data are a few examples
- Must visit various sites to obtain formats of files  
[http://www.cgrer.uiowa.edu/servers/servers\\_references.html](http://www.cgrer.uiowa.edu/servers/servers_references.html)

#### U.S. Department of Transportation – Bureau of Transportation Statistics Geo-spatial Data

- 1997 Transportation Networks databases including highway, rail, waterway, transit, and air
- All files downloaded are in DOS text format  
<http://www.bts.gov/gis/ntatlas/networks.html>  
<http://www.bts.gov/gis/ntatlas/>

#### U.S. Environmental Protection Agency Access to GIS Spatial Data Sites

- Forest Land Distribution Data for the U.S. available in Arc/Info Grid .e00 format
- Bureau of Land Management GIS data in various formats
- Various links to sites containing National geographical data  
<http://www.epa.gov/docs/oppe/spatial.html>

#### U.S. Department of Transportation – Bureau of Transportation Statistics State Site Visits

- Database information available for Georgia, Illinois, Maine, Michigan,

New York, North Carolina, Oregon, Pennsylvania, Virginia, Washington, and Wisconsin

- Must write to some states to obtain information, however some do have links to files in Arc/Info format  
<http://www.bts.gov/gis/state/visit.html>

#### MAGIC Map and Geographic Information Center – Geo-Spatial Data Resources

- A list of various states containing geo-spatial data
- States included are Connecticut, Rhode Island, Massachusetts, Vermont, New Hampshire, Maine, New York, and New Jersey
- Files are available in different formats at each site  
<http://magic.lib.uconn.edu/http/GeoSpatialDataResources.html>

#### National Transportation Data Archive

- This page provides updated data, graphs and charts on nationwide transportation statistics
- Examples are aviation, boating, highway statistics, and transborder freight data
- Files are available in numerous formats  
<http://www.bts.gov/ntda/>

#### Iowa State University Geographic Information System Database

- Information describing transportation networks, including topology and associated attribute information
- Soil information for Iowa counties, Iowa, and the United States, and supporting attribute files and interpretations
- Files are zipped in ArcView format  
<http://www.gis.iastate.edu/DataBaseNew.html>  
<http://www.gis.iastate.edu/NatlDbase.html>

#### USGS Geo-data

- Digital Elevation Models, Digital Line Graphs and Land Use and Land Cover Maps available in different scales
- Files are formatted in SDTS files or available through the ftp site  
<http://edcwww.cr.usgs.gov/doc/edchome/ndcdb/ndcdb.html>

## **Geomedia Evaluation Report**

Geomedia was evaluated with respect to its potential use for the Iowa Department of Transportation statewide coordinated management system GIS effort. The software was evaluated based on compatibility, functionality, and customization capability.

Geomedia is unique in its approach to viewing and displaying data stored in other GIS formats such as MGE and ARCINFO. Geomedia directly displays the native formats of these packages. No translation is necessary. The ability to read other GIS formats such as Mapinfo and Arcview is to be added in first quarter 1998.

Geomedia has features common among desktop mapping packages. Strengths include its ability to quickly redraw large amounts of map features and its easy-to-use map legend. Weaknesses of Geomedia are related primarily to thematic-mapping capabilities. Geomedia's thematic mapping tools are not as robust as Mapinfo or Arcview, although ranged thematic mapping is supported.

Geomedia utilizes the Visual Basic programming language to support customization. Visual Basic is a commonly used language and has many applications beyond Geomedia. Other GIS packages require programming to be done in a proprietary language designed specifically for the particular GIS package. Using Visual Basic adds a high degree of customization capability to Geomedia.

# Evaluation of the CAD Reader Extension of ArcView GIS Version 3.0a

## Objective

The objective of this task is to evaluate the CAD Reader Extension of ArcView GIS Version 3.0a for potential use by the Iowa Department of Transportation (DOT).

## Background

Through use of the CAD Reader Extension of ArcView GIS Version 3.0a, ArcView themes can be created from Computer Aided Design (CAD) files. These themes behave like other feature themes in ArcView. The CAD Reader Extension utilizes the CAD files in their native format, and file conversion is necessary only to edit or modify a CAD drawing theme.

Both Bentley's MicroStation CAD and Intergraph's Modular GIS Environment (MGE), which uses MicroStation as its CAD engine, are currently used in the Iowa DOT. All of the Department's cartographic data are currently maintained in MicroStation format, and MGE is starting to be utilized to link cartographic data, specifically roadway centerlines, to the appropriate Base Record Inventory System records. MicroStation graphic elements are linked to records in a relational database management system (RDBMS) table using a unique integer value called an "mslink". The "mslink" value is stored as an attribute both on a database record and MicroStation graphic element. The CAD Reader Extension can read the "mslink" value from a graphic element and store it as an attribute in an ArcView theme table. A new linkage between the appropriate records in an ArcView theme table and RDBMS table can be established using ArcView's open database connectivity (ODBC) capabilities. The CAD Reader Extension may allow ArcView users to view and overlay Department spatial data without performing data conversions. This may reduce the level of effort required to integrate data and potentially reduce data redundancy.

# Access Locations Pilot Project

## Introduction

Access management entails the enforced control and design and operation of entrances onto a highway system from an abutting property or local roadway. Management of access is imperative to the safety and functional capacity of the primary road system. A management program ensures that the roadway will operate in the safest, most efficient manner possible, whether in a rural or urban environment, while allowing future development and resulting levels of traffic demand.

All properties abutting a road have a right of access, therefore a management program requires the acquisition of these rights from the property owner to achieve the desired objectives. Compensation to property owners is made for the State's control of these access rights. Statutes of the State code prevail in all legal aspects of this process. The Maintenance Services Division of the Iowa Department of Transportation (DOT) coordinates the access management program for the Iowa primary road system. The roadways are classified according to the assessed management objectives, as stated in the Iowa Administrative Code 761-Chapter 112(306A). The Iowa DOT must purchase the access rights from abutting properties so as to limit the roadway access and preserve the public investment. The six access priority classifications in use today by the Maintenance Services Division are as follows:

1. Access points at interchanges only
2. Access points spaced at minimum 800 m
3. Access points spaced at minimum 300 m rural, 200 m urban
4. Access points spaced at minimum 200 m rural, 100 m urban
5. DOT has minimum access rights acquired
6. DOT has no access rights acquired

(Iowa Department of Transportation Primary Road Access Policy, pg. 4)

The process of access review on all roadway projects requires the coordination of several departments and the compilation of much information. The Access Policy Administrator must receive design plans and recommended predetermined access locations for the stated project from the Office of Right of Way and the Office of Design. The Administrator must also involve the affected cities, counties, and property owners, to collect the required documentation and legal descriptions.

Roadway maps, colored according to the six priority classifications above, provide a reference system for those needing to quickly review an existing condition or approve a proposed addition in these situations. The Access Policy Administrator, transportation center maintenance engineers, resident maintenance engineers, as well as county and municipal engineers, require such a system. The last color-coded map was produced in October, 1971, when four access priority classifications were in use, and has not since been updated.

## Project Objectives

The goal of the Access Locations Pilot Project is to produce a system that the Maintenance Services Division may utilize to efficiently update the access priority classification database and color-coded maps. As this project is under the supervision of

the Geographic Information Systems Coordinating Committee (GISCC), the system must be based on Geographic Information Systems (GIS) software. The primary user of the developed system is the Access Policy Administrator at the Iowa DOT, thus the demands of the Policy Administrator become the objectives of the pilot project.

The devised GIS program must allow the Policy Administrator the ability to update the access maps when any changes in access records may occur. Simple adjustments to priority classification, mileage extents, and location description, as well as complicated revisions including bypass additions and route relocations, will need to be reflected on future access maps. The Policy Administrator should be the sole proprietor of the access files, therefore alterations to the access files and maps need to be assigned only to that position.

The GIS program must have the capability to produce four levels of maps as required for the Maintenance Services Division. A state-wide map will show highway route numbers as well as county and city names. The regional maps will include the same labels within the limits of a maintenance district. Area maps, showing only one county, will label with the same detail. The urban level of mapping should include individual maps of cities with a population greater than 10,000 showing major street names and highway routes within the corporate limits of the town.

The GIS program should produce maps that quickly allow the user to retrieve attribute data. The Maintenance Services Division primarily wishes to view the same data used in preparing the map. GIS programs inherently provide this capability, thus the presentation of data should be in a format recognizable to the expected users. In the future, the system should be adapted to display as-built plans and photographic records of a particular roadway segment.

## **State of the Practice**

### **Other Transportation Agencies**

Access management is a necessity in all state DOT's, thus some form of data retrieval is always used to obtain access rating information. This may include paper files updated regularly, or may instead be a larger computerized database with querying capabilities. The State of Ohio maintains access records on paper in the form of maps and access permits. It is the responsibility of the 12 district engineers to keep access logs on the State's limited access facilities, update records, and regularly police these routes for violations. The district offices preserve current roadway plans on mylar sheets.

The State of New Jersey uses a database system to track access permits in the State. Using the Highway Access Permits System (HAPS), the State has the capability to track permit applications, view documents, query associated information, and check for compliance. Typical of networked database applications, specific users are granted more privileges than others in viewing this information.

Using GIS to color maps according to its attributes is an inherent trait of the various GIS programs. Thus, any department with GIS software, roadway networks, and a desire to code with access ratings, can perform this task. The state transportation departments of Pennsylvania, New Jersey, and others have accomplish this task regularly.

### **Iowa Department of Transportation**

The Iowa Department of Transportation (DOT) Maintenance Services Division currently utilizes the database capabilities of a Lotus123 spreadsheet to record changes in access control. Editing of the spreadsheet is done solely by the Access Policy Administrator with input from the transportation center maintenance engineers and resident maintenance engineers. The attribute list for each section is as follows:

1. Residency
2. Highway
3. County
4. District
5. Project From Station
6. Project To Station
7. Access Rating (1-6)
8. Side of Highway
9. Project Identification Number
10. Year of Project Completion
11. Description of Project or Section
12. Section From-Milepost
13. Section To-Milepost

## **Data Summary**

Data for this project have been retrieved from several locations within the Iowa DOT. The three original files required for this project are the primary road network and map, milepost extents for each roadway segment, and the access classification database. The Office of Transportation Data supplies the primary road network, which contains information on the interstates, state highways, and county roads. This division also provides a file containing milepost extents for each roadway segment. The primary road file contains a primary key composed of the county number, route number, county sequence number, and segment sequence number. With this key field, several other attributes, including milepost extents, can be attached. The primary roads network was originally created in an MGE project, and later converted into a MapInfo table. The Maintenance Division supplies the Lotus123 spreadsheet that is used to record the desired attributes associated with access control. Included in this file is the route and milepost extents of each access segment. This file, without GIS manipulation, is not mappable.

## **Advantages of GIS Method**

Geographic Information Systems (GIS) offer many advantages to the Maintenance Services Division in tracking the current access classifications of the primary road network. Spatial display, an innate benefit of GIS, provides a simple method to visualize geographic relations of objects on a map, rather than plain text. Conversion of the unmappable LOTUS database to an interactive, accurate map provides the Access Policy Administrator, as well as others negotiating access policy, with the ability to quickly view color-coded roadway maps, thus providing a system to visually inventory existing access classifications.

With the roadways colored according to their access rating, additional layers of data can be added to enhance the spatial analysis capabilities. Background layers of city streets and secondary roads, or city limits and land use, could underlay the colored primary road layers. As land use and adjoining roadways affect access classification, adding such layers could assist policy analysts with decision-making efforts.

A third advantage of GIS programs is their capability to perform queries and spatial analysis on all data. Information could be sought pertaining to geographic locations, route numbers, or access information. This capability would also assist engineers and planners with policy decisions.

## **Results**

Utilizing MapInfo and its underlying language, MapBasic, a user-friendly environment was created that would achieve the objectives of the project. This program allows the user to select the roadway and access information files, and automatically colors each segment according to the given access classification. Additionally, the program allows the user to label each roadway according to the primary road route designation, then places an appropriate symbol (interstate, U.S. highway, or State highway) around that number.

Maps produced are as accurate as the provided mileposting. Additional layers, where available, can be added by the user, including city and county streets, city boundaries, rail road lines, and hydrology.

The program is easy to follow, and has been tested and approved by the Access Policy Administrator. Future efforts in the production of access mapping have commenced for the 1997 year using the results of this project.

## **Conclusion**

GIS produces beneficial results in access mapping. Using existing and plentiful information, this system efficiently provides accurate maps for use by the Maintenance Services Division. Additional capabilities are provided directly from the use of GIS, such as spatial analysis and querying capabilities. Future programs will undoubtedly have the ability to display other information, such as video or sound, to accompany the existing database assets.

# Evaluation of Coordinate Systems

## 1. Objective

The objectives of this effort are to evaluate four map coordinate systems (and associated MicroStation design planes) while investigating several important coordinate system selection criteria. This effort is being conducted for the Iowa Department of Transportation's Office of Cartography.

## 2. Background

The coordinate system currently used by the Office of Cartography was established in 1986 when the office first began using computer aided drafting (CAD) software for mapping. Advancements in spatial data modeling and changing Department needs have rendered the existing coordinate system somewhat antiquated, warranting the implementation of a new coordinate system(s). Therefore, the Office of Cartography has developed three new coordinate systems for consideration. (The parameters for each of these systems, as well as the existing coordinate system, are located in Appendix A.) Upon evaluation of the coordinate systems, the Office of Cartography may select one or more of these systems for use within their office and translate existing cartography to the new system(s). In addition, one or more of these coordinate systems may be selected for standardized use throughout the Iowa Department of Transportation.

## 3. Methodology

The three basic coordinate system components, ellipsoid earth model, geodetic datum, and map projection, are reviewed. These components serve as the framework for discussing the existing and proposed coordinate systems. Emphasis is placed on the Lambert conformal conic projection, on which the existing and proposed coordinate systems are based.

Several important coordinate system selection criteria are discussed, including scale distortion, data precision and accuracy, metrication, inter/intra-agency consistency and compatibility, and data management. The coordinate systems are evaluated with respect to these criteria which provides the basis for some general recommendations.

## 4. Coordinate System Components

### 4.1. Ellipsoid Model and Geodetic Datum

The three primary components of a coordinate system are a map projection, geodetic datum, and ellipsoid earth model. An ellipsoid earth model represents the shape of the earth over the smoothed, averaged sea-surface. Geodetic datums, in turn, describe these ellipsoid models. In other words, they define the reference systems that describe the size and shape of the earth (Dana, *Geodetic*).

The Office of Cartography currently uses the Clarke 1866 ellipsoid and the 1927 North American datum (NAD27). The three proposed coordinate systems use a Geodetic

Reference System 1980 (GRS80) ellipsoid and the 1983 North American datum (NAD83). The GRS80 ellipsoid was used by the United States Defense Mapping Agency as the basis for the World Geodetic System 1984 (WGS84) ellipsoid, on which global positioning system (GPS) coordinates are based (AUSLIG). The GRS80 and WGS84 ellipsoids are essentially the same (the parameters are identical) with one minor exception, the coefficient form used for the second degree zonal (DMA, 1987).

## 4.2. Map Projection

The other component of a coordinate system is a map projection. A map projection attempts to portray the surface of the earth, or a portion of the earth, on a flat surface (plane coordinate system) (Dana, *Map*)(Richardus, 1972). Projection properties are evaluated using three, mutually exclusive, cartographic criteria: equidistance, equivalency, and conformality (orthomorphism). Projections which provide a correct representation of distance possess the property of equidistance. Projections that represent areas correctly, map areas and earth areas have the same proportional relationship, are equivalent or equal-area. Conformal projections provide correct representation of shapes (locally). The scale of the map (length distortion) is the same in every direction, lines of longitude and latitude intersect at right angles, and there is no angular distortion (i.e. lines on the grid intersect each other at the same angles as the same lines on the ellipsoid). (Canters, 1989)(Stem, 1989)

Unfortunately, all projections result in some distortions in the aforementioned properties. Minimizing distortions in some properties may maximize errors in others. However, some projections attempt to only moderately distort all properties. (Dana, *Map*)

### 4.2.1. Lambert Conformal Conic Projection

The three proposed coordinate systems are based on Lambert conformal conic projections. One projection is designed for the entire state (Iowa Lambert), one designed for the northern half of the state (Iowa State Plane, North zone), and other designed for the southern half of the state (Iowa State Plane, South zone). These Lambert projections use a secant cone projection surface, which intersects the ellipsoid along two parallels of latitude (standard parallels). A central meridian orients the cone to the ellipsoid. (Stem, 1989) The resulting scale distortion, also known as the grid scale factor, is a measure of the linear distortion "...imposed on ellipsoid distances so they may be projected onto a plane." (Stem, 1989) One meter of length on the ellipsoid is equal to the value of the grid scale factor on the projected surface.

As noted previously, the scale distortion is constant at a point and variable from point to point. Since scale distortion is dependent only on the latitude, it is constant at a parallel circle. The scale distortion is equal to one along the projected parallels, less than one between the standard parallels, and greater than one outside the standard parallels. Scale distortion may be expressed as scale error (in percent) in small scale mapping. (Stem, 1989)

The State Plane coordinate systems for Iowa were developed using Lambert conformal conic projections. Zones were designed to keep the scale distortion at less than one part in 10,000 (1:10,000), providing a third-order accuracy. In states like Iowa where

multiple zones were required, sufficient overlap of zones was provided to accommodate projects or surveys crossing zone boundaries, while still limiting the scale distortion to 1:10,000. However, it has been noted that surveyors are now accustomed to correcting distance observations by applying the grid scale factor, making the zone boundaries less important. (Stem, 1989)

The Lambert projection is most suited for a rectangular area with its greatest extents in the east-west direction, such as Iowa. (Stem, 1989)(Richardus, 1972) Additionally, the correct depiction of shape provided by a conformal projection is important in surveying and engineering. (Stem, 1989) Portraying a narrower strip of the Earth's surface will yield a smaller scale distortion in the projection. (Stem, 1989) However, areas near the edges of the map are considerably enlarged compared to near the center of the projection. (Canters, 1989)

## 5. Coordinate System Evaluation Criteria

### 5.1. Scale Distortion

Since the existing and proposed coordinate systems utilize different standard parallels, the resulting scale distortions, along common latitudes, will also differ. Therefore, the scale distortion for each system was determined at 7.5' intervals between 40° and 44° latitude. Most of Iowa's north-south extent is located between 40.6° and 43.5° latitude, with a portion of Lee County extending south to near 40.35° latitude.

Figure 1a (Appendix B) presents the scale distortions, in meters, of each coordinate system. It is apparent from this figure that the scale distortions of the existing coordinate system are much greater than those of the proposed coordinate systems. This is further emphasized in Figure 1b which presents the scale distortions of the three proposed coordinate systems only. Horizontal grid lines are plotted at the same interval as Figure 1a. In general, the flatter the scale distortion curve and nearer the curve is to the value of one, the better the coordinate systems represents ellipsoid model distances on the projected surface. The scale distortion curves for the Iowa South State Plane and Iowa North State Plane coordinate systems are fairly flat for localized areas (between the standard parallels), but the Iowa Lambert coordinate system curve is flatter across the state (analysis area) as a whole. It is also important to note that the differences among scale distortions exist between the third (thousandths) and fifth (hundred thousandths) decimal positions, see Table 1 (Appendix C). Table 1 presents the scale distortions used to generate Figures 1a and 1b. The gray, highlighted cells represent the lines of latitude between which the coordinate system's standard parallels exist.

Figure 2a presents the absolute value of the scale distortions subtracted from one (noted within this document as the "relative scale distortion"). The resulting positive values allow for easier visual comparison of linear distortions across the state. For example, the linear distortions of two different coordinate systems may be nearly the same along a given parallel, but a meter on the ellipsoid may be represented as greater than a meter in one system but less than a meter, by the same measure, in the other. The gray highlighted cells in Table 2 denote the coordinate system with the lowest relative scale distortion along each parallel. Once again, it is apparent from Figure 2a that the relative scale distortions of the existing coordinate system are much greater than those of the proposed

coordinate systems. Therefore, Figure 2b is used to present the relative scale distortions among the proposed coordinate systems only.

The impact of the scale distortions over long distances is presented in Figures 3a and 3b (and Table 3). This impact is shown as the difference, in meters, between a kilometer on the projected surface and a kilometer on the ellipsoid surface. The greatest linear distortions for the Iowa Lambert coordinate system are approximately 0.5 m/km. These distortions occur at the upper and lower (north and south) bounds of the analysis area. On-the-other hand, the maximum linear distortions for both the Iowa South State Plane and Iowa North State Plane coordinate systems are greater than one m/km at one of the analysis extents but less than 0.25 m/km at the other extent.

To further present the potential impact of linear distortions across the State of Iowa, the geodesic and grid distances between National Geodetic Survey (NGS) base stations, see Figure 4, were measured for the three proposed coordinate systems. Table 4 presents the geodesic distances, or distances along the ellipsoid model, between these base stations. Since each coordinate system utilizes the same ellipsoid model, the geodesic distances are the same for the three proposed systems. Tables 5, 6, and 7 present the grid distances between the base stations for the Iowa Lambert, Iowa South State Plane, and Iowa North State Plane coordinate systems, respectively. Tables 8, 9, and 10 present a comparison of the geodesic and grid distances for the Iowa Lambert, Iowa South State Plane, and Iowa North State Plane coordinate systems, respectively. Comparisons of the values presented in Tables 5 through 10 provide insight into the degree to which scale distortions manifest themselves over north-south extents of the state. In addition, the differing impacts of scale distortions among the coordinate systems become more apparent.

## **5.2. Precision and Accuracy**

Another important consideration in designing a coordinate system is its ability to accommodate any reasonable, expected level of spatial precision and/or accuracy within the CAD (MicroStation) design plane.

A two-dimensional design plane is defined by maximum and minimum vertical and horizontal extents and number of positional units within these extents. A position on the plane represents a unit of length, horizontally or vertically, on the plane. The level of spatial precision (or relative accuracy) that can be accommodated is considered, here, as the unit of length represented by each positional unit, or the smallest increment of length measurable on the design plane. The Department's existing coordinate system accommodates precision of one-thousandth of a mile (or 0.5280 feet), which may be inadequate for design purposes. The three proposed coordinate systems accommodate spatial precision of 0.5 millimeters over the entire state. This precision should satisfy or exceed the requirements of most applications; however, it is important to note that the coordinate system projection parameters may effect the relevancy of the available precision. For example, data collection methods, such as differential global positioning systems (GPS), have greatly increased obtainable accuracies. Yet, these spatial data (collected on the ellipsoidal earth model) must be represented on a planar surface. The manner in which these data are represented on a plane can significantly influence achievable absolute accuracies.

### **5.3. Metrication**

As noted previously, the precision (relative accuracy) of the MicroStation design plane associated with the three proposed coordinate systems is 0.5 millimeters. The distance/length measurements may be recorded in metric units, which adheres to the Department's metrication policy. The existing coordinate system is based on English units.

### **5.4. Intra-, Inter-Agency Consistency and Compatibility**

Currently, the various CAD users within the Department do not use the same coordinate system and/or MicroStation design plane. Offices, such as Design, create design planes with a specific level of precision and assign projected coordinate values to positions within the plane. On-the-other-hand, the Office of Cartography uses Intergraph's Modular GIS Environment (MGE) to assign a coordinate system to a design plane. This information is stored as part of the header of a MicroStation file. An MGE user may perform precision key-ins or read-outs of both the projected and geographic coordinates of locations within the design plane. A secondary coordinate system may also be defined, allowing the user to key-in or read-out secondary projected or geographic coordinates.

Without standards for the creation of CAD design planes and use of coordinate systems within the Department, spatial data sets describing the same geographic area can not be easily overlaid or integrated. Additionally, it is unlikely that all CAD users within the Department will use MGE, which is the case within the Office of Cartography itself. Other mechanisms must be established to insure that features are digitized at the correct geographic locations within the design plane. The design planes associated with the three new coordinate systems provide such a mechanism. Coordinate values obtained using MicroStation (only) are equivalent to the coordinate system's projected coordinate values. This is not true of the Department's existing coordinate system.

The parameters of the existing coordinate system were defined by the Office of Cartography. The resulting projected coordinates do not directly relate to the projected coordinates of a standard coordinate system, such as a State Plane coordinate system. Datum transformations must be performed to provide/recieve projected coordinate data to/from a standard coordinate system. Furthermore, the existing coordinate system can not directly accept data collected with a GPS receiver (which are based on the WGS84 ellipsoid). Geographic coordinates based on the Clark 1866 ellipsoid and NAD27 can be used without transformation.

Since the GRS80 and the WGS84 ellipsoids are essentially the same, GPS data may be used with all of the proposed coordinate systems without transformation. In addition, the two State Plane coordinate systems are consistent with the commonly used, standard State Plane coordinate systems. Many users of spatial data within the Department, and potential users of Department data in other agencies, may prefer to use a standard coordinate system, such as one of the State Plane systems. Like the existing coordinate system, the projected coordinates of the proposed Iowa Lambert coordinate system are non-standard .

## **5.5. Management**

Data management may transcend all other considerations. From a management standpoint, establishing a single coordinate system (and design plane) for use throughout the Department may lessen existing, internal spatial data consistency problems. In addition, use of a single coordinate system may better facilitate spatial data maintenance within the Department, specifically within the Office of Cartography.

Although maintaining more than one coordinate system, such as both of the State Plane systems, may be beneficial in some respects, data management may be quite challenging. However, ensuring ease in data management may compromise, or sacrifice, other important design considerations, such as accuracies (scale distortions) and inter-, intra-agency spatial data compatibility.

## **6. Recommendations**

Evaluation of a coordinate system, and its associated CAD design plane, for the Iowa Department of Transportation requires addressing considerations that are both technical and institutional in nature. Institutional issues, such as data consistency, compatibility, and management, may be as important as data precision and accuracy issues. The relative importance of these issues may be significantly influenced by the objective(s) of the coordinate system evaluation effort. For example, is the primary objective of the effort to identify a single coordinate system for use throughout the Department, to identify a coordinate system to be used primarily within the Office of Cartography, or to identify several coordinate systems that the Department will commit to support?

Therefore, it may be appropriate for the Department to identify more specific objectives with respect to the coordinate system evaluation effort. Upon identification of these objectives, the Department may review the evaluation criteria presented in this report, add criteria not addressed and/or remove criteria deemed inappropriate/unnecessary, and prioritize the resulting evaluation criteria.

Such a prioritized evaluation criteria, however, is not essential for all recommendations. Several recommendations, primarily technical in nature, apply regardless of a clarified evaluation criteria. The first recommendation is to discontinue use of the existing coordinate system and adopt one, or more, of the proposed coordinate systems. Each of these coordinate systems utilize a Lambert conformal conic projection. As stated previously, the Lambert projection is most suited for a rectangular area with its greatest extents in the east-west direction, such as Iowa. (Stem, 1989) Furthermore, a conformal projection provides a correct depiction of shape, which is important in surveying and engineering. (Stem, 1989)

Use of the NAD83 datum is also recommended. A growing number of data collection efforts within the Department are utilizing GPS receivers to obtain spatial, locational data. Since the NAD83 datum is based on the GRS80 (WGS84) ellipsoid, GPS coordinate data may be used with each of the proposed coordinate systems without datum transformation. Conversion from raw WGS84 geographic coordinates to equivalent projected coordinates will be necessary for MicroStation-only users. Most GPS receivers possess the capability to convert raw WGS84 geographic coordinates to equivalent projected coordinates for standard coordinate systems, such as Iowa State Plane systems.

Conversion from raw WGS84 geographic coordinates to equivalent projected coordinates for the proposed Iowa Lambert coordinate system will likely require MGE Basic Nucleus and MGE Projection Manager, or another external mechanism.

Adoption of the Iowa Lambert, Iowa South State Plane, Iowa North State Plane coordinate system is as institutional in nature as it is technical in nature and may greatly depend on prioritized evaluation criteria. Regarding accuracy and minimization of scale distortion, adoption of both State Plane systems may be most appropriate. The two State Plane systems are standard coordinate systems commonly used both within the Department and by external agencies. However, managing two different coordinate systems and CAD design planes may be quite challenging. Issues likely to result from such an undertaking include the development of statewide cartographic coverages and tiling and displaying coverages from different projections.

A potential solution may be to adopt either the Iowa South State Plane or North State Plane for the entire state. Although standard projected coordinate values may be calculated and used within either the coordinate system (over the full extent of the state), it may be uncommon to use Iowa North State Plane coordinates in the South zone, and visa-versa. Scale distortions also increase outside of the area for which the coordinate system was designed.

Another potential solution may be to adopt the Iowa Lambert coordinate system. Although the scale distortions for the Iowa Lambert coordinate system are greater than the Iowa State Plane coordinate systems for portions of the state, the distortions are, on average, less than both of the Iowa State Plane coordinate systems across entire extent of the state. The Iowa Lambert coordinate system is not a standard coordinate system, which may limit its ease of use, both within and outside of the Department.

Regardless of which coordinate system(s) is adopted, the secondary coordinate system supported by MGE should be utilized. The secondary coordinate system allows the precision key-in and read-out of geographic and projected coordinates of a coordinate system other than the primary coordinate system. The secondary coordinate system need not be based on the same ellipsoid model or datum as the primary coordinate system. Potential uses of the secondary coordinate system may include: adopting an Iowa State Plane coordinate system as the primary system and defining the secondary coordinate system as the other Iowa State Plane coordinate system; adopting the Iowa Lambert coordinate system as the primary coordinate system and defining the secondary coordinate system as a more standard coordinate system; or adopting a primary coordinate system and secondary coordinate system which do not utilize the same datum. Many other potential uses of the MGE secondary coordinate system exist and should be evaluated based on the adopted coordinate system(s). MicroStation-only users will not be able to directly utilize the secondary coordinate system.

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# **Detours and Routing Pilot Project**

## **Introduction**

The initiation of the Intelligent Transportation Systems (ITS) brings a need for advanced traveler information systems (ATIS). Such systems can include use of the Internet, giving travelers advanced notice of road conditions, closures, and detours.

## **Project Objectives**

The Construction Sites and Detour Locations Pilot Project was combined with the Routing Pilot Project as a result of the similarities in objectives. The goals of this combined project are to produce a system that the Iowa Department of Transportation (DOT) may utilize to efficiently create and update a map of construction sites and road closures with recommended detours. As this project is under the supervision of the Geographic Information Systems Coordinating Committee (GISCC), the system should be based on Geographic Information Systems (GIS) software. The primary users of the developed system will likely be Field Services Division, thus the demands of the Division become the objectives of the pilot project.

The system must develop a database of road closures and construction sites. Information in this database may be identical to that in the Iowa Detour and Road Embargo Map. This format must be able to be easily and quickly updated.

The system should also have the ability to route around the road closures and construction sites. This routing may be based on user-defined criteria including, but not limited to, bridge limits, pavement width, and functional classification.

The devised system must make available to the public road and routing information by means of the Internet. This process should be as automated as possible to limit the time commitment from DOT personnel and hasten the process of making the information available.

## **State of the Practice**

### **Other Transportation Agencies**

An Internet search around other state DOT's found that many agencies have maintained maps showing construction projects with access to descriptive information and detours. These are often accompanied by real-time traffic congestion maps. An in-depth search, contacting the authorities responsible, found that the construction maps were maintained by other personnel outside the departments using advanced software techniques. These techniques were not known to include GIS software, but other Internet technology. Traffic congestion maps are produced by advanced mapping software using traffic counters and real-time processing software.

### **Iowa Department of Transportation**

The Iowa DOT disperses such information in two methods. The DOT currently maintains Internet sites providing helpful roadway information including links to regional weather forecasts as well as a text-only listing of Iowa road closures. In addition, a

printed version of the road closures, the Iowa Detour and Road Embargo Map, is produced by the Maintenance Services Division and distributed statewide.

## **Data Summary**

Data for this project have been retrieved from other efforts in mapping. The roadway network, comprised of primary, secondary, and city streets, is the compilation of efforts in a DOT Coordinated Management project. Information for the primary roads from the Base Records is included in this mappable file.

## **Results**

Two separate GIS software packages were investigated for their capabilities in providing the desired results. Maptitude is one GIS package that has a routing capability within, thus an obvious choice for the routing objectives. MapInfo is a full-functioning GIS package, but does not include a routing routine, a deficiency that can be corrected by customizing the environment with MapBasic programs to perform such a task. Either GIS program is capable of displaying the detour and construction site locations. Maptitude was unable to perform the routing objectives satisfactorily as a result of errant data transfer. The roadway network could not be imported properly into the Maptitude environment, resulting in line breaks and mismatched data. This problem caused an inability to route, as the program continuously returned no values.

The customization capabilities of MapInfo with its underlying MapBasic language were utilized to perform the routing necessities. This routing calculation was based on the shortest path algorithm, executed entirely within the MapInfo environment. The shortest path is based on the summation of link scores along the route, with each score derived from user defined factors. A link contained within the extents of a project or road closure is scored as if impassable, thus routing occurs around, never through, such impediments. The routing tasks can be handled efficiently and easily with the MapInfo and MapBasic programs, however, this program is insensitive to many variables. Key elements, such as how the project data could be entered into the system, were difficult to address.

Currently, project information could be entered with other written programs if route and milepost extents are known. However, on secondary roadways without mileposting, a manual selection of affected links is necessary to construct the project location. Other methods, such as GPS data collected in the project area, could be used, but can also be time consuming to incorporate.

Another factor in routing calculations was ignored. This element, the extent to which the project affects traffic flow, is ignored. As the linework only consists of roadway centerlines, the existing routing program cannot distinguish between travel directions, or if traffic flow is still permitted through the construction zone. The routing programs simply route around, never through, the impediments addresses as a road closure.

The user-friendly environment of this GIS program provides a simple means to achieve the construction location and routing capabilities, however no completely automated process could be found to display these results in Internet protocol. Several varieties of software exist that have the capability of producing an image supplying direction to other Internet sites. These could produce a map image that allows the user to obtain further information on an area of the map by clicking that sector. This action produces another

Internet page that could contain detailed information on the recommended detour, construction project, or road closure. A prototype of this concept was developed and included on the Internet site for this project. Another ongoing project for the Iowa DOT is focused solely on the ability to display such crucial information on the Internet.

## **Conclusions**

A user-friendly system was constructed that quickly allows routing to be performed when project information is already available. However, there is no automatic ability with which to convey this information on the Internet. An additional study is underway to somewhat automate this process. Further study is necessary to refine the routing model, for it is possible to give this program the capability of understanding directionality and permissiveness of traffic flow through the project.

# **PARCEL TRACKING**

## **INTRODUCTION**

The Iowa DOT's Right of Way (ROW) Design Section is responsible for the design of right of way along new highway projects. They perform much of the design work in Microstation, a computer aided design (CAD) software package. ROW Design often requires the parcel information such as owner, area, and access control to make decisions. Parcel data are stored in the DOT's parcel tracking system, an IDMS database. The ability to access IDMS data through CAD graphics will facilitate better decision making through easier access to parcel information. This report is an evaluation of six methods of establishing an interface between CAD graphics and the parcel information.

## **OBJECTIVE**

The objective of this project is to evaluate methods for linking graphical parcel data from CAD software with parcel tracking information for the Iowa DOT's Right of Way (ROW) Design Section.

## **STATE OF THE PRACTICE**

### **IOWA DOT ROW**

Currently, the Iowa DOT ROW Design Section uses Microstation, a CAD package, to draft the right of way and parcel boundaries. If they want information on certain parcels of land, the parcel tracking database is available to them. This data base is in the IDMS format. It consists of a series of screens of information concerning each parcel. It is cumbersome for ROW to view each screen to find the information they need.

## **ADVANTAGES OF INTEGRATING GRAPHICS AND IDMS DATA**

The advantage of integrating CAD graphics with the IDMS information is that parcel information would be in a single accessible environment. The data available in the IDMS system would be accessed when the user selects a parcel. This ability improves decision making by allowing the user to get a broader understanding of a problem.

## **RESULTS**

This project was an evaluation of several options that ROW Design could use to link the CAD system (Microstation) with information from the parcel tracking database (IDMS)

### **Desktop Mapping Option**

Desktop mapping describes a class of GIS software that is relatively inexpensive and easy to use. The process involved with using desktop mapping for this ROW

application would be to import graphics from Microstation and a text file from the IDMS system into the desktop mapping software. The text file and the CAD graphics would be linked by a common identifier such as the parcel number. Desktop mapping would allow for a wide range of future applications beyond merely linking text and graphics. It allows for querying based upon attribute information and the incorporation of geographical data sets from a breadth of sources including other DOT offices, the Department of Natural Resources, and municipal and county tax assessor offices. On the other hand, using desktop mapping would require the maintenance of a set of files separate from CAD. As for the functionality, using a separate application would not allow the DOT to obtain the parcel information from within Microstation.

### **Microstation Tags**

Microstation has the intrinsic ability to associate a text tag with a graphical element. This tag could include owner information, parcel number, etc. However, each tag must be entered individually. The functionality of the tag tool was not designed for quick information retrieval by the user. As a result, a long record cannot be viewed in its entirety. Once entered, selections can be based upon tag values. A way may exist to automate this procedure, using MDL or MicrostationBasic, but it hasn't been developed.

### **Geopak**

The DOT currently uses Geopak Civil Design Software, which is a Microstation add-on, in the Office of Design and is beginning to use it in ROW Design. Geopak contains tools for the highway design process. Geopak's parcel and ROW tools allow the storage of information with graphical elements, but the information for each parcel must be individually entered. This means that a text file from the IDMS file could not be automatically associated with the CAD graphics using Geopak. It does allow for a text file to be plotted with the plans, but this information is not associated with the graphics, other than appearing on the plotted plans. Using Geopak to store and retrieve parcel information would not allow data from IDMS to be incorporated in any automated fashion.

### **Microstation With A Relational Database**

Microstation has the ability to interface with a relational database. With this functionality, it can link graphical CAD elements with entries in the database, allowing the user to take advantage of the database's tools. However, IDMS is not one of the relational databases supported by Microstation. This means that the DOT would need to maintain a separate data base, in addition to IDMS. Again, each of the CAD elements must be individually associated to a database record.

### **Microstation/MGE/Relational Database**

MGE is a full function GIS package which works with Microstation and a relational database. MGE, like the desktop mapping method, would allow for a wider range of future applications. However, it is expensive and would require more training than the previously methods.

### **Third-Party Interface**

A consultant could develop an interface between IDMS and Microstation. This would tailor the interface specifically to the needs of the DOT and eliminate the need to maintain a separate database. The product would be easier to use, but would require a significant initial investment. Moreover, such an interface would restrict the possibility of future applications.

# **ACCIDENT AND ROADWAY/ROADSIDE FEATURES**

## **INTRODUCTION**

The Iowa Department of Transportation (DOT) Maintenance Division and the Office of Transportation Safety are working together to correlate roadside safety features with accident rates. The use of geographical information systems (GIS) may make this process simpler because of its spatial analysis capabilities. This project aims to identify and correlate roadside safety features with accident rates using a desktop GIS.

## **OBJECTIVES**

The objectives of this project is to develop a GIS database of spatial-based associated roadside safety features data and accident locations in the Scott County area. Recommendations will also be made for procedures on identifying and correlating the spatial-based associated data with accident rates.

## **STATE OF THE PRACTICE**

### **OTHER TRANSPORTATION AGENCIES**

There is a total of more than 40,000 deaths and more than 3.5 million disabling injuries caused by traffic accidents each year. These result in a societal cost of more than \$100 billion every year. Many of the efforts at improving highway safety have been effective, however more effort needs to be put into decreasing the amount of roadside crashes. The total number of deaths due to car accidents has decreased over the years, but roadside crashes have stayed constant.

Other transportation agencies have researched and written papers on roadside safety and what possible measures need to be taken to improve this safety. Many transportation agencies such as the Texas Transportation Institute (TTI) perform full scale automobile and truck crashing simulations in order to develop and improve roadside safety hardware. Research by transportation agencies has shown that many times the safety features are not manufactured or installed properly. This has led to many injuries and fatalities. Therefore, agencies are trying to develop roadside safety features which are less sensitive to installation variation, low maintenance, and should function under unusual but expected environmental conditions.

Transportation agencies are also doing research to determine which roadside features need to be treated. They're developing methods which will be able to predict the frequency or rate of impacts and the resulting severity of the impact. They are also working on ways to estimate injury severity savings if the safety feature is improved.

Currently most state data files are not sophisticated enough to link a crash injury with a specific object and because collecting roadside inventory is very labor intensive

there's not a lot of information on roadside safety features. Therefore, not a lot of research has been done on a

correlation between roadside safety hardware and accident rates. Of the research that has been done, very few of it has been done using GIS.

## **IOWA DOT**

The Iowa DOT Maintenance Division and the Office of Transportation Safety are working together to correlate roadside safety features with accident rates. The Iowa DOT Safety Division has developed an accident location and analysis system (PC-ALAS). Users can obtain accident statistics for locations during specified time periods. Queries can be done to identify accidents of specific types. Analysis of these accidents are being done, such as why accidents are occurring, and to identify ways to reduce the number and severity of the accidents.

The Maintenance Division has also been working on The Roadside Safety Feature application for Windows. This application provides a way for entering inspection and inventory data into a computer database at the on-site location using a laptop computer. Currently, only data on guardrails in the Davenport area have been entered into this database. The Iowa DOT is looking for a way to conduct their analyses of roadside safety features and accidents. GIS has been recognized as having great potential in this area, although applications have not been developed to this point.

## **ADVANTAGES OF GIS ANALYSIS FOR ROADSIDE SAFETY FEATURES**

### **GIS ANALYSIS**

GIS has many advantages in analyzing the safety of roadside safety features. One advantage is spatial display. It is a lot easier to comprehend the relation between certain objects if this relation is seen on a map rather than as a list of locations. Another advantage of GIS is the ability to overlay multiple layers. This allows the user to see a picture of how different objects on separate layers may be related, such as guardrail locations and accident locations. A third advantage of GIS is its analytic capabilities. A user can visually investigate a data set and also quantitatively analyze it. An example of a GIS's quantitative analysis is the ability to perform queries and spatial analysis (e.g., finding all of the guardrails located in Scott county).

The overall benefit is that not only can a user plot the accident and guardrail locations, but he will also be able to do such things as highlight guardrails which were constructed using beams and highlight accidents with a high severity code. This information could then be used to make informed decisions about the design or the locations of the guardrails.

### **DYNAMIC SEGMENTATION ANALYSIS**

Dynamic segmentation is an effective way of creating a map that includes a primary road system, guardrail locations, and accident locations, along with attribute information. Dynamic segmentation is fairly procedure once the user understands some basic concepts.

The Iowa state's roadway files are segment-oriented, while the event tables are feature-orientated. Events are records in a database that contain attributes along linear features using a route-measure system. The geometry for the events is dynamically determined based on their measured values. These events may be linear (such as the guardrails) or points (such as the accidents). Environmental Systems Research Institute, Inc. (ESRI) has a dynamic segmentation model that consists of routes and sections organized into route-systems. A route-system is a collection of routes with a common system of measurement. A route is an ordered collection of arcs or sections used to represent linear features, while a section is the arc or portion of an arc used to define each route. Each of these sections is assigned a from and to position (such as beginning milepost and end milepost).

There are two feature attribute tables that make it possible to have multiple route-systems in a single ARC/INFO coverage. These tables are the route attribute table (RAT) and the section table (SEC). These additions are automatically created and maintained by ARC/INFO. They are stored as INFO data files and help define the route-system. Routes and their attributes are stored in the RAT. The RAT contains a unique identifier, a user identifier, and a user-defined route key item (such as the route number). The route key item is used to link events to the route. Sections are utilized in a SEC table. The SEC also contains a unique identifier and a user identifier, as well as a from measure and a to measure. Figure 1 illustrates the relationships between the RAT, SEC, and the event tables.

Dynamic segmentation can now take place. Event tables are related to the routes by linking the event key item and the route key item in the RAT, and the measures in the event table are compared with the measures in the SEC. Dynamic segmentation occurs when the route's measures are dynamically proportioned to the correct measures in the event tables.

Dynamic segmentation has many advantages. The most important benefit is that it can associate multiple sets of attributes to any segment along a route without changing the description of that segment. It has the ability to link attributes to linear features using a route-measure format. In this way, all of the information on the route is preserved as well as the information on the events. The events will be shown in the correct location along the route and the attribute information will be linked to the events. Another advantage of dynamic segmentation is that it will store, display, query, and analyze these attributes, without segmenting or breaking the route with pseudo nodes.

## **PROCEDURE**

### **POSSIBLE METHODS**

Three different types of GIS software were analyzed in order to find the method that would give the most accurate results. The three types of software analyzed were MapInfo, ARC/INFO, and ArcView. MapInfo was investigated first for two major reasons. Most importantly, the software would be economical for the DOT. Secondly, the software is user friendly and fairly easy to learn.

A Map Basic program was created that ideally would link the guardrail data to the primary road system in MapInfo. However, a Map Basic program could not be created that would give the results desired. The program was not able to include all of the guardrail locations in the data set. This was due to the fact that when there was a guardrail located on the left side and the right side of the same section of roadway, the program would override one of the guardrails and, as a result, the map showed that there was a guardrail on only one side of the roadway. Due to these errors, it was decided that MapInfo would not give the best results possible. *ADDENDUM: (not known to original author) A MapBasic program was written that could achieve the desired accuracy in plotting guardrail and accident information. This program was created months after the author/researcher finalized the project report. The results of this new program have yet to be tested against those of the researcher.*

ARC/INFO was the second type of software that was analyzed. ARC/INFO has many capabilities including dynamic segmentation. Dynamic segmentation was performed in ARC and the results were plotted in ARC/PLOT. The results were reasonably accurate, however there are some disadvantages to ARC/PLOT. One of the disadvantages is that there are quite a few command lines that must be typed in ARC and in ARC/PLOT each time the map is displayed on the screen. Secondly, quite a few command lines are necessary in order to perform even the simplest query. Finally, this

program does not have pull down windows, and therefore, is not user friendly. Because of these disadvantages this process would become very time consuming and is not a very economical method.

The final type of software that was analyzed was ArcView. ArcView has many of the capabilities that ARC/INFO has, including dynamic segmentation, however it is much more economical and user friendly than ARC/INFO. It has a pull down menu system that makes the software simple to use. Queries are also fairly simple to perform. The biggest disadvantage of dynamic segmentation in ArcView is that there are two important steps that, at this point, must be done in ARC. However, ArcView is still the best, most accurate method of these three possibilities.

## **PROCEDURE USING ARCVIEW**

### ***Event Tables***

The guardrail data was received as a FoxPro text file from the DOT. This table contains guardrail information for the Davenport area (which includes Scott, Clinton, and Jackson Counties). The information that is included is route, costcenter, county, milepost, station, side of highway, post type, number of posts, guardrail length, guardrail type, end anchor type, and current condition. This was imported into ArcView first as a text file. The table was then exported as an INFO file and then imported back into ArcView. This was done for two reasons: ArcView will not make corrections on text files and dynamic segmentation will only work if the event tables are INFO data files. The event table had to be edited in order for the dynamic segmentation to give accurate results. Unnecessary columns were deleted, records were corrected, and changes were made to the route column so that the format matched the format of the route column in the route-system exactly (i.e., route 6 must be a character that reads "0006"). Finally, the end mileposts of the guardrails were calculated by adding the guardrail length to the beginning milepost. The end milepost values may not be completely accurate because mileposts are not exactly one mile apart, however, because the length of the guardrail is so small errors are negligible.

Accident PC-ALAS node map data was then received from the DOT for Scott County. These nodes were in the form of microstation CAD UOR's (units of resolution). The x and y justification UOR's were extracted from this file using a Map Basic program. Using Intergraph MGE (a fully functional GIS) eastings and northings were created with the x and y justification UOR's. The eastings and northings projection is Universal Transverse Mercator Zone 15. Next, the eastings and northings were combined with the PC-ALAS node map data using a FORTRAN program. The x and y justification UOR columns could then be deleted from the PC-ALAS node map data file. Finally, the Scott County editfile was obtained by the DOT and two columns were created and updated in this file using MapInfo. These updated columns are the eastings and northings.

The editfile was then exported in MapInfo as a dbase file and imported into ArcView. The file was then exported as an INFO file and imported back into ArcView. This was done for the same reasons it was done with the guardrail data. This event table also had to be edited in order for the dynamic segmentation to give accurate results. Unnecessary columns were deleted,

records were corrected, and changes were made to the route column so that the format matched the format of the route column in the route-system exactly.

### ***Route System***

A statewide primary road system data file was obtained from the DOT and the Scott County, Clinton County, and Jackson County records were extracted from this data file in MapInfo. This file is linked to graphics and includes the county, route, lane length, county sequence, segment sequence, beginning milepost, and end milepost. This file was edited in MapInfo and was brought into ARC/INFO using ArcLink. The file prim.e00 was imported into ARC using the IMPORT command as a coverage called primary.

The next step was to unsplit the primary sections so that a section of roadway begins at one intersection and ends at the next intersection. This was done using an AML program called unsplit.aml. This guaranteed that there no gaps exist in the line work. The beginning and ending milepost information was found for the new sections by looking at the milepost information at the intersections in the original line work. The coverage with corrected line work is called primary3. This coverage includes only the beginning and ending mileposts, the county, and the route, but after the dynamic segmentation is completed the original coverage (primary) can be added to the display so that all of the attribute information will be accessible.

### ***Dynamic Segmentation Process***

The first step in dynamic segmentation is to create a route-system within the coverage which contains the RAT table and the SEC table. The ARCSECTION command in ARC creates a named route-system with sections that are grouped together by specifying an item in the primary3 coverage. The item used to group sections together will be the route number. The name of this route-system will be guards. This groups all arcs having the same route number into one route. The resulting route-system has two tables attached to it, a primary3.ratguards table and a primary3.secguards table.

The next step is to open the primary3 coverage (it's a theme in ArcView), the guardrail event table, and the accident event table in ArcView. The final step in dynamic segmentation is to open the View menu and select "add event theme". Dynamic segmentation will be done by the route theme method. The guardrails and accidents are now displayed on a map along with the primary and primary3 themes. Items such as the legend, colors, line width, etc. can now be changed to meet specific needs. Many

queries can be performed simply by pressing the Query Builder icon at the top of the Display Window and building logical expressions using specific attributes. For example, select accidents with a high severity code and change the color of these accidents on the map. Next, visually determine whether these accidents are located near guardrails or not.

## **CONCLUSION**

GIS can be very beneficial in increasing the safety of roadside safety features. It gives a visual image of where objects are located on a roadway in relation to other objects. ArcView lets you explore databases, display all or part of its contents, display and save results, and perform spatial or logical queries. Using this, one will have the ability to identify and correlate the spatial-based associated data with accident rates, if there are correlations. This GIS database does not replace any other methods that are currently taking place at the DOT, but it will serve to enhance them.

## APPENDIX I STEPS TO COMPLETE DYNAMIC SEGMENTATION

1) ARC/INFO is accessed through Vincent. The first step is to telnet to a terminal that has the ARC/INFO application. These terminals are currently located in the GIS lab in Durham on the Iowa State University campus.

```
vincent% telnet tremplo.gis
vincent% xhost +
vincent% arc
```

2) The next step is to import the file prim.e00 into ARC using the IMPORT command as a coverage called primary.

```
Arc: import cover prim primary
```

3) Next, run the AML program which unsplit the sections.

```
Arc: &run unsplit primary3
```

One must manually select each section that needs to be unsplit. After this has been completed, the coverage must be rebuilt in order to save all of the changes that have been made.

```
Arc: build primary3 line
```

4) The ARCSECTION command in ARC creates a named route-system with sections that are grouped together by specifying an item in the primary3 coverage. The item used to group sections together will be the route number. The name of this route-system will be guards. The resulting route-system has two tables attached to it, a primary3.ratguards table and a primary3.secguards table.

```
Arc: arcsection primary3 guards BR_ROUTE # beg_mlpst end_mlpst
```

5) All of the files that have been created by ARC along with the primary3 coverage can be moved to a directory on a PC that has ArcView or ArcView can be accessed through Vincent by typing **arcview** at the vincent prompt. If telneting from a PC, Micro X-Windows must be available. This Microsoft Windows program turns a PC into an X Window system server. This is needed so that graphics can be displayed from the host computer.

6) Once in ArcView, choose Views, and click on the "new" button. A screen pops up with an empty window. Open the View menu at the top of the Display Window and select "add theme". Open the primary3 theme and the primary theme.

Next, choose Tables, then click on the "add" button. Open the guardrail table and the accident table. Any corrections that need to be made on these tables can be made in ArcView.

Once corrections have been made to the event tables, open the View menu at the top of the Display Window and select "add event theme". Click on the route theme icon in the upper left corner. Select the correct route theme, event table, and fields within these tables in order to link the event tables to the route theme correctly. Use the columns that have the route number for the Route field and for the Event field. The From field will be the column in the guardrail event table that has the beginning milepost, the To field will be the column in the guardrail event table that has the end milepost, and the Location field will be the column in the accident event table that has the milepost location. Click on "OK". Dynamic segmentation has been completed.

Open the File menu at the top and select "save project".

7) Now the symbols, line thickness, line color, etc. can be modified on the map. ArcView also has the ability to perform many types of analyses and queries on this data.

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# Utility Locations Pilot Project

## Introduction

A knowledge of utility locations is necessary for many divisions of the Iowa Department of Transportation (DOT). Information about utility companies, services, and locations within the roadway right-of-way (ROW) is essential when excavation work is performed around a roadway. Accurate locating of facilities can avoid damage to buried lines and can facilitate the planning process and preconstruction meetings associated with roadway construction. As increasing numbers of utility companies must locate within the limited ROW, the odds of a contractor moving something besides dirt are getting better all the time.

Utility companies supply information to the Iowa DOT in many forms. In the permitting process, an Application for Use of Highway Right of Way for Utilities Accommodation is filed with the DOT's utility superintendent and is accompanied by plats and detailed, scaled drawings. The permit is then approved by the superintendent and may also require the approval of the city and the Federal Highway Administration.

The placement of above-ground utility structures within the ROW is dictated by the clear zone distance for that roadway. This clear zone distance is defined in Chapter 3 of the American Association of State Highway and Transportation Officials' *Roadside Design Guide*. This measure is derived from the roadway design speed, slope geometry, and traffic volume. Obstacles posing a risk to errant vehicles must be beyond this clear zone distance. Mitigation programs serve to identify obstacles violating this principle.

## Project Objectives

The goal of the Utility Locations Pilot Project is to produce a system that the Maintenance Services Division may utilize to efficiently create and update a utility locations database. As this project is under the supervision of the Geographic Information Systems Coordinating Committee (GISCC), the system should be based on Geographic Information Systems (GIS) software. The primary user of the developed system is the Utility Superintendent at the Iowa DOT, thus the demands of the Superintendent become the objectives of the pilot project.

The system must be compatible with the policies of a mitigation program. This may include the ability to calculate the distance from the roadway to an above-ground facility, and assess a penalty to each facility located within the calculated clear zone distance.

The system should also have the ability to automate the permitting procedures, producing a paperless process. Such methods could include use of the Internet and World Wide Web to provide an on-line application for utility companies. Additionally, the database and map of utility locations should be updated automatically with the use of this system.

## State of the Practice

### Other Transportation Agencies

No other state transportation departments were found to maintain an electronic database of utility locations. All projects required the use of "one-call" organizations to provide

the necessary information. Many states require utility companies to register with such organizations.

Such "one-call" agencies maintain databases of utility companies referenced to geographical areas. These geographical areas may be the boundaries of township sections or city blocks. The "one-call" center maintains a listing of all utility companies with facilities in that area, then uses this list to respond to requests for locating services. The utility companies within that sector are notified of a construction request, and are responsible to individually locate their facilities if the construction site is potentially imposing. Such systems are in use in nearly every state, particularly Illinois (J.U.L.I.E), Ohio (O.U.P.S.), and New Jersey.

### **Iowa Department of Transportation**

The Iowa DOT utilizes a "one-call" agency for its utility location needs. The State of Iowa requires utility companies to register with Iowa One-Call. This agency is supplied with various forms of information in both paper and electronic form. This data is then fed into a rudimentary GIS system and can be queried by the operating staff of the agency. Land Manage is the software that ties the operators to the GIS database. The accuracy of the maps this agency produces from the given data is around 100 to 150 feet. When a contractor notifies Iowa One-Call of a project requiring excavation, the agency then places a buffer zone on its maps encompassing the site. This buffer zone may have a radius of 200 feet in an urban environment, or 500 feet in a rural location.

## **Data Summary**

Various attempts were made to collect accurate information in the construction of a GIS database. Numerous authorities predicted a lack of cooperation from the various companies for reasons of confidentiality. Also, many companies are in the process of producing their own fledgling GIS databases, and may not willingly supply information to others for the same purpose. Several major utility companies were found to exhibit these traits.

Two counties, Black Hawk and Polk, were chosen as the pilot areas for two reasons. First, several ROW files exist for various roadways within this county. Also, utility companies and government agencies are actively pursuing the creation of GIS maps. Later in the progress of the project, it was decided to solely pursue Polk County utilities as a result of more plentiful data with respect to Black Hawk County. Specifically, the roadways for which utility information would be collected is along U.S. Highway 65 near Bondurant and State Highway 28, the border between Des Moines and West Des Moines. The Iowa DOT was sought for its information on ROW extents and clear zone distances. The Right of Way Office maintains a few CAD files of recent roadway projects, with a listing of such files found in the strip map book. These files are very extensive and detailed, however, only a few exist and a very small percentage of the entire roadway system is recorded. These CAD files have no ties to a coordinate system or earth projection for use in a GIS map. Additionally, with the detail of the files, excessive information and linework is contained that would complicate a conversion process for GIS mapping.

In Polk County, the Central Iowa Area Mapping (CIAM) project develops accurate maps for various uses. High-resolution aerial photographs have been used for digitizing

roadways and lot lines, originally intended for the Polk County Auditor's Office. Utility companies jointly share these files, using them in a one-way exchange for their own digitizing needs. The total size of these files exceeds the needs of this project, however they could be imported into a GIS environment.

In Black Hawk County, the county engineer's office was active in developing accurate maps of the roads within. The county engineer, Harold Jensen (now Story County Engineer), developed digitized files from accurate aerial photographs. However, utility companies in this county, with the exception of Cedar Falls Utilities, have not used this information to develop maps of their own facilities.

MidAmerican Energy (MAE), the predominant utility in Polk County, has utilized the information from the CIAM project to produce maps of its facilities. MicroStation files were forwarded from MAE for this project that contained inadequate information for use in a GIS environment. These files contained excessive linework, and its facilities did not have any associated attribute information. MAE uses additional files in an Automated Mapping/Facilities Management (AM/FM) format for its network analysis. Neither of the two formats would be easily incorporated into this GIS project, but the company is slowly progressing in its efforts to produce its own GIS maps and databases in some urban areas of Iowa. Personnel with MAE estimate that completion of the Des Moines metropolitan area would not occur for approximately five years.

Cedar Falls Utilities (CFU), used the digitized aerial photos from Black Hawk County. These files are accurate to "a couple of feet", but have the same problems as those of MAE in Polk County.

U S West Communications, the phone company for Polk County, has used the information from the CIAM project to create digitized maps of their facilities. There are concerns about data confidentiality that will affect the availability of data. In the summer of 1996, the Data Management Division was dissolved, and this project was too late in receiving any attention before the closing period of U S West.

Some cities within Polk County maintain CAD files for the utilities they operate. From preliminary collection of data from the Des Moines Waterworks, West Des Moines Waterworks, and the City of West Des Moines, these data files present the same difficulties as all others collected. These problems included excessive linework, lack of geographic references, and inability to attach attribute information.

## **Results**

The ability to obtain a GIS database directly from the utility companies was not attainable. Although numerous CAD files were supplied, there were several problems inherent with each. CAD files could be overlaid on existing GIS maps with the use of control points. This method requires identifying a minimum of four points on the CAD drawing and matching them to points on the GIS map. As a result, the GIS software registers the CAD drawing, thus giving it an earth projection. This method could have been utilized, but the excessive linework and lack of attribute information would have made the efforts useless.

The use of Global Positioning Systems (GPS) was investigated to collect information for a utilities database. Using hand-held receivers and the Iowa DOT GPS log van could be used to collect coordinates of the desired facilities. Both methods are time intensive and dependent on the equipment being used.

In an attempt to salvage the project outcomes, an investigation was begun into the use of an Internet form to automate the permitting process. A sample form was created that mimics some of the information from the Application for Use of Highway Right of Way for Utilities Accommodation. This sample form can be found on the WWW page of this project. The format and content of this page can be easily modified to the desires of the Iowa DOT.

A form on the Internet is created with the standard Hypertext Markup Language (HTML) to be displayed on a WWW browser. Various HTML tags format the placement, size, and type of input areas. These include, but are not limited to, text spaces, radio buttons, check boxes, and pull-down menus.

Within the language of an Internet form, a Uniform Resource Locator (URL) links this form to another Internet site. This site, rather than showing another HTML document (or web page) instead contains a specific program that was written to read the data from the form. Such programs are known as Common Gateway Interface (CGI) programs, and more commonly referred to as CGI scripts. This program can then reply with an HTML document to the computer that sent the form, send an HTML document with relevant information to another computer, or directly access a database. This program can be written in almost any computer language, but is frequently written in whatever language a particular server interacts with most frequently.

Writing CGI scripts is beyond the scope of this project, however the constructed form does have its information processed at another Internet site. Test scripts are located on a WWW server at the University of Illinois Urbana-Champaign. This CGI script returns an HTML document to the computer from where the form was sent, reporting information that was written in the form.

## **Conclusions**

Although the objectives of the project were not attained, the lessons learned from these efforts could assist in further research for the Iowa DOT.

Noting the problems encountered with utility companies and their available information, attempts could be made to request information in other formats. Measurements could be taken from the digital maps and transferred to a coordinate system format such as latitude/longitude. This information can be read into a database and processed through a GIS program to produce a map of the utility locations.

With an Internet form, Common Gateway Interface programs could be written that access a database directly. The WWW server would have to be fitted with this capability and the appropriate programs written. This database can be imported into a GIS program for the production of location maps.

Any database of utility locations or utility permits can be queried according to the desired properties in a mitigation program or permits processing application. Using Structured Query Language (SQL), the standard database querying principles, this information processing can be performed. However, constructing a database of such attributes and collecting the information are the first steps.

For more information on CGI scripts and constructing Internet forms, browse the Internet, or visit the sites of:

<http://kuhttp.cc.ukans.edu/info/forms/forms-intro.html>

(much of the project information on CGI scripts and forms obtained here)

<http://hoohoo.ncsa.uiuc.edu/cgi/forms.html>

# **ROADSIDE DEVELOPMENT PILOT**

## **INTRODUCTION**

The Iowa Department of Transportation (DOT) is required by Section 404 of the Clean Water Act to replace wetlands which are dredged or filled in for highway projects. The Iowa DOT's Roadside Development Section (RDS) is responsible for the identification of wetlands impacted by highway projects and the mitigation of damages to these wetlands. Geographic information systems (GIS) are computing tools used for the storage, display, and analysis of geospatial data. RDS identified three stages of their wetlands mitigation process which could be enhanced using GIS: preliminary wetland impact identification, delineation of impacted wetlands, and monitoring of mitigation sites. This pilot project is an effort to identify GIS procedures which would enhance these three steps and to test these procedures in a current RDS project.

## **OBJECTIVE**

The objective of this project is to evaluate the usefulness of GIS in three stages of Iowa DOT's wetland mitigation process: preliminary wetland impact identification, delineation of impacted wetlands, and monitoring of mitigation sites.

## **STATE OF THE PRACTICE**

### **RESEARCH EFFORTS AROUND THE NATION**

Other agencies at various levels of government, have investigated the use of GIS in wetland mitigation. The U.S. Army Corps of Engineers (USACE) sponsored a wetlands workshop<sup>1</sup> at which the entire spectrum of wetlands research was discussed, including identification, delineation, and monitoring. The North Carolina Division of Coastal Management (DCM) used GIS to map existing wetlands and identify wetland function. They utilized National Wetlands Inventory (NWI), Landsat Thematic Mapper (TM) satellite images, and soil survey data sources.

North Carolina's DCM and the North Carolina DOT (NCDOT) reported on projects involving mitigation site identification. The DCM project used GIS with NWI and TM, U.S. Geological Survey (USGS) hydrography coverages, and soil survey data sources to identify and prioritize potential wetland mitigation sites. The NCDOT used hydrological modeling methods to predict the success or failure of a mitigation site.

Louisiana State University, the Louisiana Department of Natural Resources (L-DNR), USACE Waterways Experiment Station, and UC-Davis reported on methods of monitoring wetlands. These

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<sup>1</sup> National Interagency Workshop on Wetlands, U.S. Army Corps of Engineers

projects involved collecting field data of various types (water, soil, and atmospheric conditions, long term trends, infrared aerial photography, planting survival rates, etc.) to monitor the growth, shrink, and/or health of mitigation sights. The L-DNR project used GIS to create maps tracking the shrinkage or growth of wetlands over time.<sup>2</sup>

While the use of GIS in each of these projects varied in complexity, they show that GIS is a widely used tool in wetlands research. The results of this research will be implementation of GIS around the nation in a variety of wetland analysis applications, including identification, delineation, and monitoring.

## **IOWA DOT ROADSIDE DEVELOPMENT SECTION**

The Iowa DOT is required by Section 404 of the Clean Water Act to replace wetlands which are dredged or filled in for highway projects. The current process begins when right-of-way (ROW) plans are finalized. The RDS uses paper maps to identify areas of hydric soils crossed by the ROW. Field surveys investigate these areas looking for other wetland indicators including vegetation and hydrology. Once a wetland is positively identified, RDS must delineate it to estimate its size and type. RDS then consults local offices (e.g. Ducks' Unlimited, Natural Resources Conservation Service, county conservation office, etc.) to identify sites in proximity to the project that could support a wetland of similar size and type. RDS visits these sites to determine what type of wetland the site could support and the effort involved in creating it. Once a particular site is picked and built, RDS must monitor the wetland for five years to ensure that the wetland establishes itself. After the five year period, the wetland is handed over to a local authority for supervision and upkeep.

## **ADVANTAGES OF GIS IN WETLANDS MITIGATION**

The use of GIS offers several enhancements to the current methods used by the DOT in the areas of preliminary impact identification, impact delineation, and mitigation monitoring.

## **PRELIMINARY IMPACT IDENTIFICATION**

The primary method the DOT employs in identifying possible impacted wetlands is the identification of hydric soils along the route. The area containing these soils will be inspected by field survey to verify whether or not a wetland exists. GIS could aid this phase of the process by allowing the user to graphically identify areas of hydric soil that are intersected by the project. With the ability to create a buffer of given radius around the an object, GIS could identify all of the hydric soil areas within 100' of centerline. GIS will save time over the current method of drawing or taping the proposed route on paper soil survey maps.

## **IMPACT DELINEATION**

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<sup>2</sup> "Monitoring Wetland Restoration by Integrating GIS and Image Processing Technology with Continuous Data Collection," Gregory D. Steyer, Louisiana Department of Natural Resources.

The delineation of impacted wetland boundaries is often an estimate made from field notes. The area of the wetland is approximated from the delineation to determine the amount of land to be mitigated is made. The field survey also includes information on vegetation, hydrology, wildlife, and soil used to determine the type of wetland being impacted. GIS could enhance the delineation phase of the process through its drawing capabilities and its ability to underlay aerial photography and to store data. With a GIS, the boundaries of a wetland could be drawn digitally over an aerial photo image. Once it is drawn, the area of a wetland is calculated automatically. The data storing capabilities of a GIS allow for the storage of non-graphical information collected by the field survey.

## **MITIGATION MONITORING**

During the mitigation monitoring stage, the DOT verifies that the mitigation site is surviving. They report annually for five years to the USACE on the status and health of the site. GIS could aid the monitoring phase by providing a system on which notes and photographs from field surveys are stored and georeferenced. It could also enhance graphical and statistical preparation for the annual reports.

## **RESULTS**

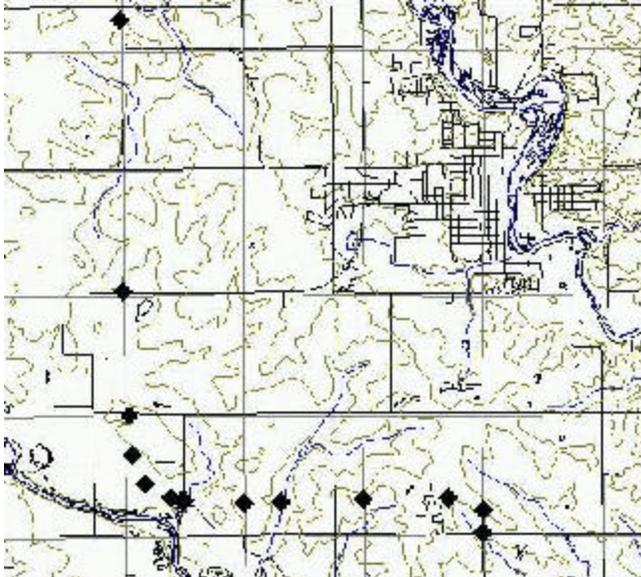
The DOT identified the Waverly, Iowa bypass of U.S. Highway 218 as the study location for the first two phases of the pilot project. Because the Waverly bypass was not yet in the monitoring phase at the time of the project, the DOT identified the Denver, Iowa bypass of U.S. Highway 63 as the study location for the third phase of the pilot project. The project utilized MapInfo as the GIS software.

## **PRELIMINARY IMPACT IDENTIFICATION**

In the first stage, the project involved drafting the proposed route in GIS and using other data sets to identify potential wetland sites. The existing data included scanned aerial photographs from the DOT and roads, rivers, section boundaries, and topographic data from the Iowa DNR Natural Resources GIS Library (NRGIS) internet site.<sup>3</sup> A considerable amount of time was spent scanning and registering the aerial photos to their geographic locations. The registering process consisted of identifying common points on the aerial photo and on the map layers and associating the photo to those points. When these points did not coincide perfectly, the GIS distorted the digital layers to fit the photo image. This distortion resulted in the control points being the only geographically correct points on the photo. Since the photos were of a higher precision than the digital maps (1:2,400 for the photos, compared to 1:100,000 for the maps), the natural tendency was to consider the photos as geographically accurate when they were not. Care must be taken when using the aerial photos for coordinate references, such as locating the centerline or delineating wetlands.

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<sup>3</sup> NRGIS internet site. <http://www.igsb.uiowa.edu/htmls/nrgis/gishome.htm>



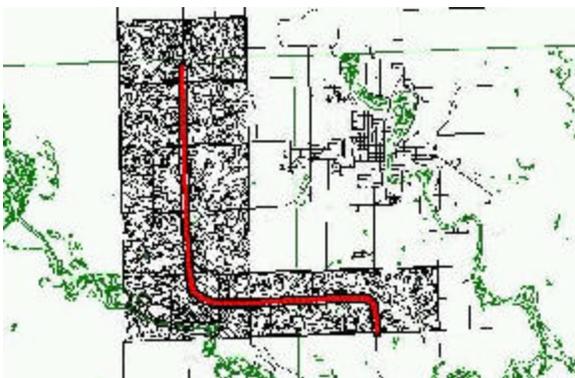
**Figure 1. Route control points established with GIS layers of roads, rivers, topography, and section boundaries.**

The DNR data sets came in e00 format on a county-by-county basis. Download and translation from e00 to MapInfo format took approximately 15 minutes per data set. After the data were translated, the route control points were located and drawn using the measuring and drawing tools in GIS. Figure 1 shows the route control points for the Waverly bypass with the DNR data sets. When Global Positioning System (GPS) survey data become available to RDS, drafting the proposed route will be unnecessary, as GPS will produce accurate centerline coordinates.

Once the centerline was drafted, the National Wetlands Inventory (NWI), county soil survey, and hydrography geospatial data led to the identification of impacted wetlands. The NWI is a GIS coverage of bodies of

water larger than three acres identified from aerial photography. It was developed by the U.S. Fish and Wildlife Service and is available free-of-charge to the public over the internet.<sup>4</sup> The conversion process from NWI's DLG format to MapInfo is complex.<sup>5</sup> The digital county soil surveys, digitized from soil survey maps, are available from the Natural Resources and Conservation Service (NRCS) office at Iowa State University.<sup>6</sup> A list of hydric soils is also produced by the NRCS. The list, together with the

digitized maps led to the identification of hydric soil areas. Hydrography is available over the internet from the NRGIS site. Figure 2 shows the proposed route with soil, NWI, and transportation data. As a side note, a comparison of NWI wetlands and hydric soils in the project area showed that not all of the NWI wetlands were located in areas of hydric soil, and not all hydric soils contained NWI wetlands.



**Figure 2. Route shown with NWI, transportation, and soil survey data.**

The project used GIS to create a 100m buffer to estimate the ROW around the route centerline. This buffer identified all of the hydric soils, NWI

<sup>4</sup> NWI internet site. <http://www.nwi.fws.gov/>

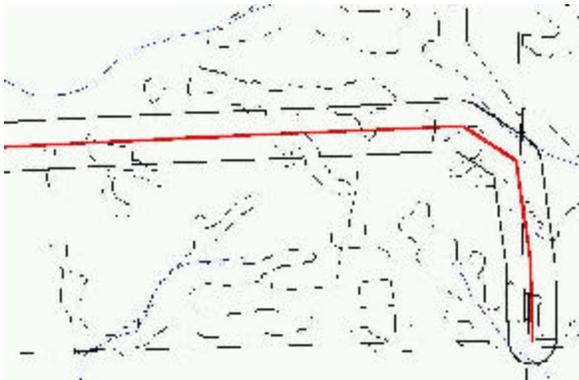
<sup>5</sup> There is a utility for direct conversion for the graphics from DLG to MapInfo, but it does not capture the associated data (e.g. wetland type). For this project the DLG files were converted to Arc/INFO first, and subsequently to MapInfo.

<sup>6</sup> This data was available for Iowa State projects at \$1/section. The price for non-university projects was not stated.

wetlands, and streams that intersect the estimated ROW. Figure 3 shows the identification of hydric soils within 100m of the route near the Beginning of Project (BOP). These data sets could be used to create maps for the field surveyors to use in the field to mark the boundaries on.

### IMPACT DELINEATION

Once potential wetland sites are identified the sites would be visited by RDS personnel to determine the extent of wetlands. The second stage of the pilot project involved using GIS to draw the extents of the impacted wetlands and to build a database for notes from the field visit. The boundaries were drawn using GIS tools (Figure 4). Although aerial photos were used to locate the wetland, this may not have accurately located the real-world position of the wetland due to the previously mentioned problems which arose from scanning and registering the aerial photographs. If more accurate positioning is required, GPS may provide the needed accuracy. If the exact location of the wetland is not required, the photos provided an excellent guide and visual display. The GIS automatically calculated the area of the delineated wetland (Figure 5). A database for storing field notes (Figure 6)

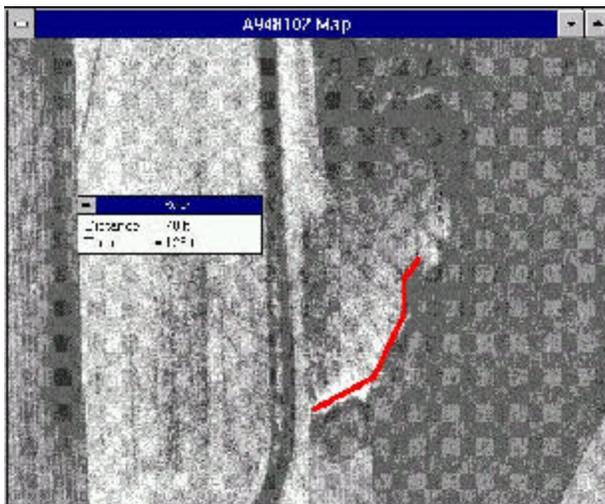


**Figure 3. Proposed centerline with 100m buffer identifying areas of hydric soils near the BOP.**

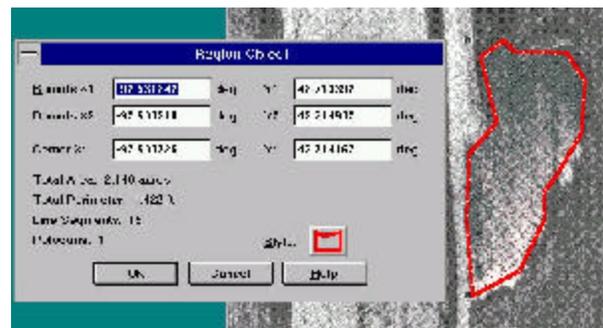
was a means for storing dates, numerical data, and short comments, but was inconvenient for storing longer notes. Since each record was stored on a single line, working with longer records became difficult to display. For longer comments, the data base could contain a summary and a reference to where the comments are located, either a text file or hard copy.

### MITIGATION MONITORING

The third stage of the project involved drawing the boundaries of mitigation wetlands in the GIS and building a database to maintain notes. Although much of the processes of this stage were similar to those in



**Figure 4. GIS measuring tool used in drafting impacted wetland.**



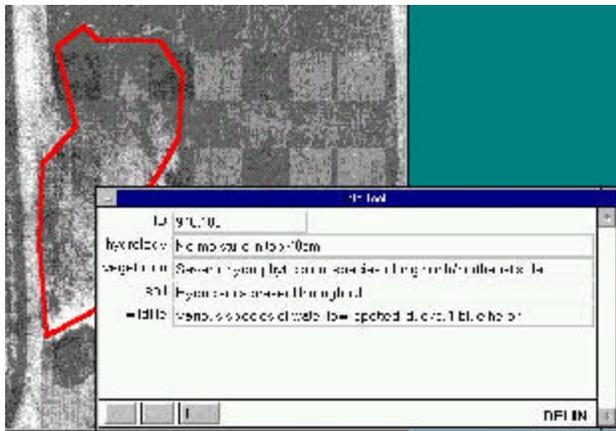
**Figure 5. GIS used to perform area calculations.**

the previous stage, its purpose was to monitor changes and progress in the mitigation sites over a period of five years.

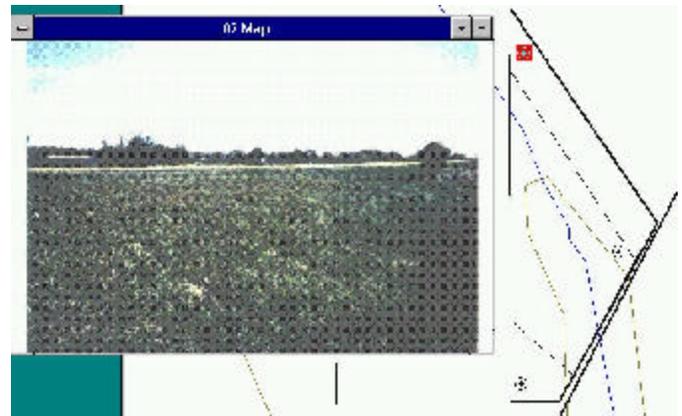
Similar to the impact delineation phase, GIS with its drawing and measuring tools was used to record the graphical extents of the wetland (Figure 7). Again, GPS would produce more accurate real world coordinates of the wetland boundaries. Another useful tool for the monitoring phase was the ability of GIS to reference photographs of the site to the location the photo was taken. "Clicking" on a photo location accessed the photo shown in Figure 8. Many of the desktop mapping features of GIS would aid in producing graphics for reports or public meetings. Tabular data could also be stored and analyzed with GIS (Figure 9) to prepare data and statistics for reports and presentations.

### FUTURE POSSIBILITIES

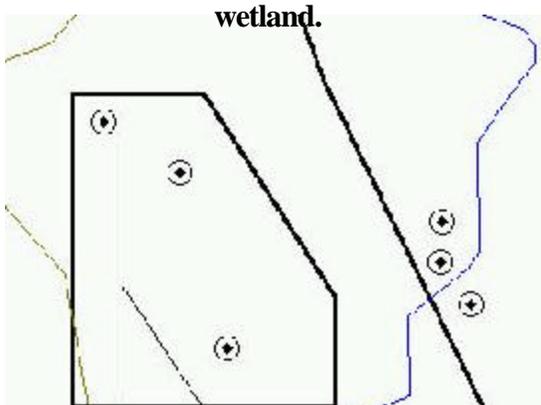
Using GPS to establish the route centerline and wetland locations has already been mentioned as one future application. As GIS is implemented at the Iowa DOT, another future possibility emerges. GIS could be used to facilitate a smoother design process, from planning through to mitigation and maintenance. The usefulness of GIS to project planning has been addressed in the Project Planning



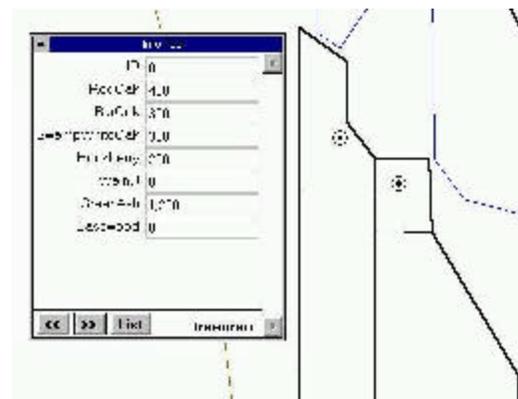
**Figure 6. Data base set up to record and store field notes from field survey. Data base information is accessed by clicking on the wetland.**



**Figure 8. Photograph taken at mitigation site, Denver, Iowa. Photo was accessed by clicking on the point in the map.**



**Figure 7. Created map of mitigation site.**



**Figure 9. Data base created to track tree plantings.**

Level Data Pilot Project. In an integrated design process, the Office of Project Planning would use a wide range of GIS data as they analyze a corridor. When route control points are established, they would be passed on the Office of Design and eventually to RDS. After the mitigation project is completed, the GIS files could be passed on to the maintenance personnel for their duties.

## CONCLUSIONS

The process of wetlands mitigation in highway construction projects involves several stages. GIS was applied to three of these stages to evaluate its usefulness: preliminary impact identification, impact delineation, and mitigation monitoring. GIS allowed for the incorporation of spatial data from other sources, drawing of wetland boundaries, storage of field notes, and creation of graphics. These functions enhanced the three stages of the wetlands mitigation process through the identification of suspected impact sites using soil and wetland data, the graphical creation of wetland boundaries with and storage of field data with GIS, and the preparing graphics for public meetings and yearly reports. Current DOT practices in the wetlands mitigation process could be enhanced with GIS.

# **PROJECT LEVEL DATA**

## **INTRODUCTION**

The Iowa Department of Transportation (DOT) Office of Project Planning (OPP) analyzes corridors for future DOT highway projects. The use of geographic information systems (GIS) may enhance their current work in two ways: first, through data sharing with other GIS users; and second, through the GIS's spatial analysis capabilities. This project seeks to evaluate the usefulness of GIS to project planning in these two areas using World Wide Web (WWW) resources in a desktop GIS environment.

## **OBJECTIVE**

The objectives of this project are to download data sets from the WWW and to evaluate their usefulness to the duties of the Iowa DOT OPP.

## **HARDWARE RECOMMENDATIONS**

The recommended system for running a desktop GIS is a Pentium P5 or P6 150MHz machine with 16Mb of RAM (32Mb preferred). It should have two gigabytes of disk space, an ethernet connection, WWW access, and run Windows 95 or NT. The cost for this would be approximately \$4000.

A scanner or plotter may also be required, depending on the application. A flatbed color scanner (8.5" x 14" or larger) is recommended for applications involving scanning aerial photographs, graphics, or photos from field surveys. Approximate cost is \$300. A HP 750C, E-size inkjet plotter with a minimum of 48 Mb of RAM is recommended for applications involving plotting large posters for public meetings. Approximate cost is \$8000.

## **STATE OF THE PRACTICE**

### **OTHER TRANSPORTATION AGENCIES**

Other transportation agencies have written papers on their use of GIS for corridor planning, environmental assessment, or preliminary design. These projects involved a significant investment in the creation of data through field surveys as well as the use of data from other sources. West Virginia DOT created basemaps for a project area from 1:1000 scale aerial photos. The thrust of their project was to improve the interaction between engineers and environmental scientists in the alternatives development stage using GIS. They concluded that GIS improved the design process.

GIS enables a concurrent approach to preliminary alignment development and environmental investigation, that results in a shorter overall time requirement; facilitates alignment adjustments; provides for retrieval and dissemination of information;

complies with various regulations, and produces analytical evaluation of impacts. And while many time-saving and cost-cutting techniques often sacrifice quality, the GIS improves quality.<sup>1</sup>

The British Columbia Ministry of Transportation and Highways used GIS with Computer Automated Drafting (CAD) and highway design software in their preliminary design and environmental assessment. They used aerial photos, Global Positioning Systems (GPS), and survey data to create basemaps. These basemaps were given to environmental consultants who marked their findings on the maps. Later, these findings were recorded in the database. They summarized the following.

GIS has demonstrated its power as a tool in support of corridor selection, environmental impact analysis, public information sessions, notification requirements, and engineering design.<sup>2</sup>

These projects involved an investment of time and money in the collection of data beyond the scope of this project. The maps created by these projects are at a much smaller scale than those available to the public through the WWW. Nevertheless, these projects show the usefulness of GIS to project planning.

## **IOWA DOT OFFICE of PROJECT PLANNING**

The responsibility of the Iowa DOT OPP is to develop alignments for highway projects and to assess their impacts on the environment. Currently, once an alignment is developed, the OPP seeks evaluation of the alignment from various government authorities (federal, state, county, and municipal). These evaluations consist of notifying OPP of other conflicts along the alignment, including underground storage tanks, wetlands, flood plains, or possible habitats of endangered species. In some cases, the OPP may need to change the route of the project, while in other cases, the OPP may address the conflict areas by mitigating the damages.

### **ADVANTAGES OF WWW GIS DATA**

#### **DATA SHARING**

The amount of geospatial data available to the public has increased dramatically in recent years. The U.S. Department of Interior established the Federal Geographic Data Committee (FGDC) in part "to coordinate spatial data activities of federal agencies" which includes "providing wider access to geospatial data."<sup>3</sup> With federal leadership and coordination, the amount and quality of geospatial data

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<sup>1</sup> "GIS and the Highway Development Process," Proceedings GIS-T Symposium 1994; Christopher Gesing and Patricia Gesing, Michael Baker Jr., Inc.

<sup>2</sup> "GIS Applications to Assessment of Environmental Impacts of Planning and Preliminary Design of the Vancouver Island Highway," Paper prepared for presentation at the 1991 TAC Annual Conference; Robert MacDonald, Michael Kent.

<sup>3</sup> FGDC Homepage; <http://fgdc.er.usgs.gov/fgdc2.html>

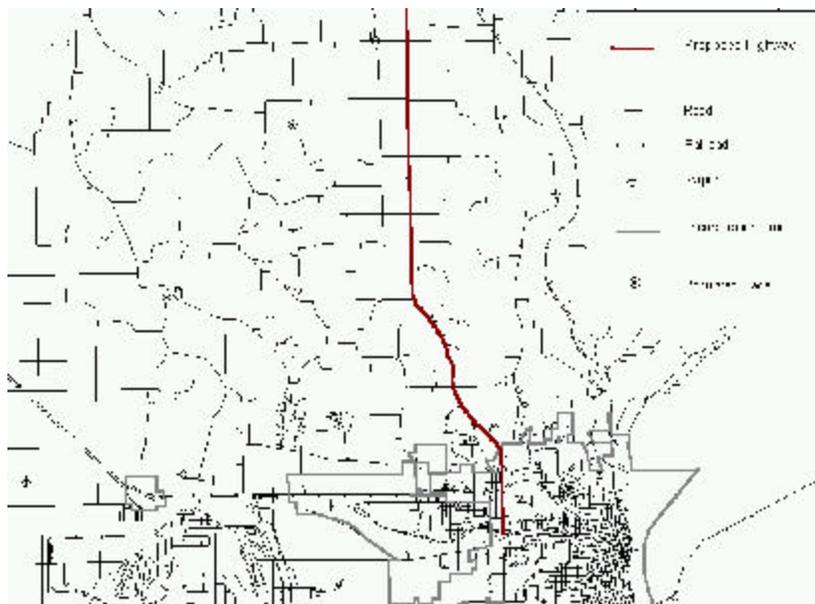
available will only improve. The WWW is the medium of choice for distributing geospatial data. According to the Iowa Department of Natural Resources (DNR), "The Web is an exciting new way to deliver GIS information services."<sup>4</sup>

Using other agencies' data available on the WWW can save time, mistakes, and money. Other agencies have labored to collect and maintain data and most are willing to share it to prevent an overlap of effort by other agencies. Most of the data available to download must pass certain standards and must include documentation (metadata). Use of quality data leads to fewer mistakes attributable to errors in the data, while quality metadata leads to fewer mistakes based on a misinterpretation of the data. WWW download sites are free and look to remain so for the near future.

Specifically for the OPP, the use of shared data offers an advantage in the ability to assess a wider database of corridor restraints without leaving the office. This leads to more efficient route planning. Better information obtained in the beginning, will decrease the chance for changing alignments later in the project when corrections are more expensive.

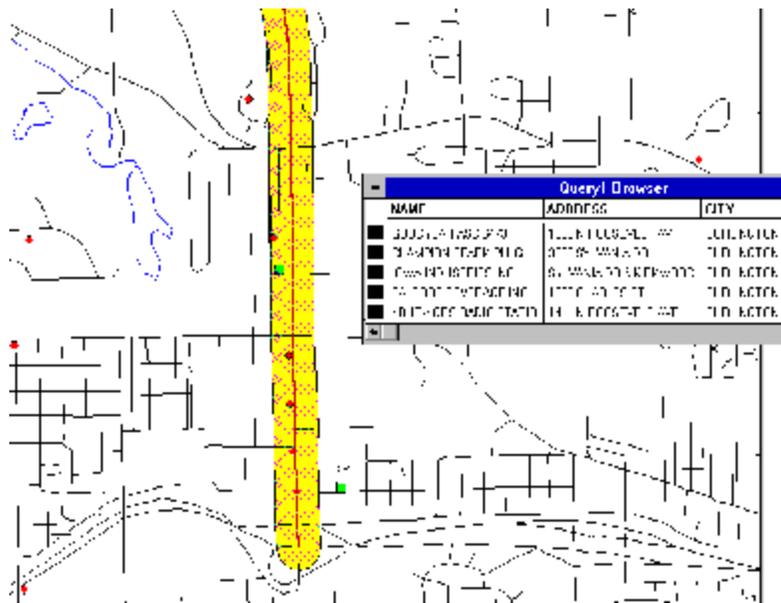
## GIS ANALYSIS

A GIS offers several benefits to project planning. One is the simple advantage of spatial display. In the task of locating objects in relation to one another, a map leads to better comprehension than a list of locations. Another benefit of GIS is the ability to overlay multiple layers. This allows the user to see a truer picture of the difficulties present in the field. While a layer of topography may suggest one location for a route, adding the floodplains may lead to a different location. Figure 6-1 shows an example of spatial display and overlaying with GIS.



**Figure 6-1. Spatial Display and Overlaying of Cultural Features Around a Proposed Route.**

A third benefit of GIS is its analytic capabilities. A user can not only visually investigate a data set, but can quantitatively analyze it. One example of a GIS's quantitative analysis is the ability to perform queries like a common database (e.g., finding all of the cities with a population greater than 5,000). Another example of quantitative analysis is a GIS's ability to perform spatial analysis (e.g., finding all of the public wells in Des Moines County). A GIS can also create buffers around objects. Figure 6-2 contains an example of buffering coupled with spatial analysis to find the underground storage tanks within 100m of a proposed route.



**Figure 6-2. Buffering and Spatial Analysis Identifying Underground Storage Tanks within 100m of Proposed Route.**

Another capability of GIS is the ability to underlay images. These could be aerial photos or satellite images. This project did not evaluate this functionality because of the time involved in scanning and registering small scale aerial photographs.

## FINDINGS

### **GIS SOURCES ON THE WWW**

The primary source for Iowa geospatial data on the WWW is the DNR Natural Resources GIS Library (NRGIS) site. The NRGIS site contains county level data sets of roads, rivers, topology, and the Public Land Survey System, as well as a large collection of statewide data sets. The NRGIS data is

available in Arc/INFO export (e00) format, recognized by many GIS packages<sup>5</sup>. Another WWW site offering geospatial data for Iowa is the Scientific Assessment and Strategy Team (SAST) homepage. This site contains a variety of geospatial data for the north central region of the U.S. collected for the scientific community after the floods of 1993. This data is available in Spatial Data Transfer Standard (SDTS) format<sup>6</sup>. The National Wetlands Inventory (NWI) is distributed in Digital Line Graph (DLG) format from the NWI homepage. Iowa State University's (ISU) GIS Lab also has a large collection of geospatial data available from its WWW site. These sites have some overlap of data sets, but each also offers a few unique data sets. Table 6-1 is a summary of these WWW sites. Other WWW sites exist which contain descriptions of geospatial data, but the data is not available for download and must be ordered through the mail. These include the State Soil Survey (STATSGO) and Soil Survey (SSURGO) data bases and the US Forest Service land boundaries.

Two particular issues arise in using shared data. First, as each GIS package has its own data format, the format of data on the WWW varies. This presents complications in translating data to a specific GIS application. The data may need to be imported to one GIS and then exported in a different format which can be read by the second GIS. Second, the scale at which the data was originally collected varies. While some data sets were originally 1:24,000 scale, others were 1:250,000, and still others are of unknown scale. The user needs to understand that the relationship of one dataset to the other on the computer screen may not be exactly the relationship found in the field.

**Table 6-1. Summary of WWW Geospatial Data Sites.**

WWW Address	Name of Site	Extent of Coverages	Type of Coverages	Data Format
<a href="http://www.igsb.uiowa.edu/htmls/nrgis/gishome.html">http://www.igsb.uiowa.edu/htmls/nrgis/gishome.html</a>	NRGIS	Iowa	Cultural, Environmental, Geological	e00
<a href="http://edswww2.cr.usgs.gov">http://edswww2.cr.usgs.gov</a>	SAST	North- central U.S.	Cultural, Environmental, Wildlife	SDTS
<a href="http://www.nwi.fws.gov">http://www.nwi.fws.gov</a>	NWI	U.S.	Wetlands	DLG
<a href="http://www.gis.iastate.edu">http://www.gis.iastate.edu</a>	ISU GIS Lab	Iowa	Cultural, Environmental, Soil,	e00

**COMPARISON OF GIS AND TRADITIONAL METHODS: U.S. 61 PLANNING STUDY**

OPP identified a pilot project area in southeastern Iowa. The project is a realignment and widening of U.S. 61 from Burlington to the junction with Iowa 78 near Mediapolis. The project used

<sup>5</sup> MapInfo, AtlasGIS, ArcView, and Maptitude all offer utility programs that will import e00 files.

<sup>6</sup> SDTS is a standardized geospatial data format supported by the federal government. Many agencies are already using SDTS as their transfer format. Iowa DNR has said that they plan to move to SDTS in the future. Currently, import functions only exist for more sophisticated GIS packages, but that is expected to change as the demand for SDTS translators increases.

MapInfo as the primary GIS. MapInfo is one of the top three GIS in sales and is one which ISU's Center for Transportation Research and Education (CTRE) personnel are familiar with.

### **Data Collection**

The WWW sites utilized in the pilot project were the NRGIS, SAST, and NWI sites. The process of collecting the NRGIS data consisted of downloading, uncompressing, and translating each of 30 data sets into MapInfo. The time involved in processing a single data set varied from 5 to 30 minutes depending upon file size and Internet speed. Table 6-2 contains a list of the NRGIS data sets used for the pilot.

**Table 6-2. NRGIS Data Sets Used in Pilot Project.**

Data Set Name	Description	Scale / Accuracy
PLSS29, PLSS58	Township, range, and section for each county	24,000 / 22m
Rivers29, Rivers58	Rivers for each county	100,000 / 52m
Roads29, Roads58	Roads for each county	100,000 / 52m
Topo29, Topo58	Topography at 10m intervals for each county	100,000 / 52m
Airports	Airports	NA
IABG	Block Groups	100,000 / 52m
DNRLands	Lands owned or maintained by the Iowa DNR	NA
Highway	Major Highways	100,000 / 52m
Incorp	Boundaries of incorporated Cities and Towns	100,000 / 50-100m
Places	All populated places	NA / 100-150m
Abandon	Pre 1989 registered, plugged wells	NA / 275m
Abwell91	1989-91 registered, plugged wells	NA / 275m
Luse	Land use from 1975-84	NA
Muniwu	Wells and intakes for cities with pop. > 25,000	100,000 / 220m
Privwell	Registered private wells since 1987	NA / 140-570m
Ustsites	Permitted underground storage tanks	NA
Wateru	Wells and intakes with rate > 25,000 gpd	NA / 1140m
Wwtp	Waste water treatment plants	NA / 1100m
Brgeo500	Bedrock geology - 1969	500,000 / 1100m
Brtopo	Bedrock topography	100,000/ 100-3200m
Basin100	Drainage basins	100,000 / 235m
Lakes92	Lakes	24-100,000 / 210m

Landform	Landform regions	1,000,000 / 2000m
River500	Major rivers	500,000 / 570m
Sinkhole	Sinkhole Locations	200,000 / 500m

The process of collecting a single SAST data set involved finding the USGS 100,000 reference quad, downloading, uncompressing, translating into Arc/INFO<sup>7</sup>, exporting in e00 format, and importing the file to MapInfo. The time involved varied from 20-40 minutes per data set, again depending on file size and Internet speed. Table 6-3 contains a list of the SAST data sets used for the pilot. One drawback to the SAST datasets is that metadata is not available and thus the scale and accuracy are unknown.

**Table 6-3. SAST Data Sets Used in Pilot Project.**

Data Set Name	Description	Scale / Accuracy
Fldpln	Floodplains	NA
NPL	Environmental Protection Agency's (EPA) National Priority List (Superfund) sites	NA
TRI	EPA's Toxic Release Inventory Locations	NA
Rail	Railroads	100,000 / NA
Birds	Bird habitats	NA
Mussel	Mussel locations	NA
Wildlife	Wildlife habitats	NA

The process of collecting the NWI data involved downloading, uncompressing, translating into Arc/INFO, exporting in e00 format, and importing each data set to MapInfo. This process varied from 20-40 minutes. The NWI data is 1:24,000 scale, but the positional accuracy is not available.

### **Corridor Conflicts Identified with GIS and Downloaded Data Sets**

The buffering and spatial querying of the GIS led to the identification of objects from the downloaded data sets within 100m of the project. Identification of the following areas took approximately 3 hours with GIS. It is important to note the accuracy of the data set when analyzing a query. A more thorough analysis might include buffering at different radii to account for varying levels of accuracy. For instance, the sinkhole coverage is accurate within 500m, so a 500m buffer could be used to make sure that no sinkholes are located near the project. The NWI is accurate within 50m, so a 50m buffer would suffice.

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<sup>7</sup> Arc/INFO is a more sophisticated GIS package and one for which an SAST translator already exists. Arc/INFO can then export the file in e00 format, which MapInfo can import.

## **Landuse**

The route passes almost entirely through agricultural land with a small area of forested land a few miles north of Burlington. Starr CAVE STATE PRESERVE is located near the Beginning of Project (BOP) in Burlington. The route also passes through Newport, an unincorporated town.

## **Topography**

The route begins at about 200m. It crosses the Flint Creek valley and rises to 220m. The route is somewhat level the rest of the way aside from crossing the Smith Creek valley. It also crosses three intermittent streams: Paul Creek, Hawkeye Creek, and Yellow Spring Creek.

## **Sinkholes**

There are several sinkholes located near the BOP in Burlington.

## **Underground Storage Tanks**

One registered underground storage tank is within the 100m buffer. It is registered to MEDIAPOLIS SCHOOL BUS GARAGE, BLAINE STREET, MEDIAPOLIS.

## **Railroads**

The route crosses three railroads. One is located south of Mediapolis, the other two are north of Mediapolis.

## **Wetlands**

The following wetlands are identified in the National Wetlands Inventory. The following list includes township, range, section number, the number and type of wetland and approximate acreages. The five letter identification code is identified below the listing. The listed acreage are for the entire wetland, not just the area intersected by the GIS buffer zone.

T73N,R03W, Section 22, one PUBGh ~.8 acres  
T72N,R03W, Section 2,3, five PUBGh total ~3.9acres  
T72N,R03W, Section 3, one PEMC ~<1/4 acre  
T70N,R03W, Section 11, three PUBGh ~1.8 acres  
T70N,R03W, Section 14, two PUBGh ~2.6 acres  
T70N,R03W, Section 24, three PEMC ~1.1 acres  
T70N,R03W, Section 24, one PUBGh ~0.9 acres  
T70N,R03W, Section 24, one PFO1C ~7.1 acres  
T70N,R03W, Section 24, one PSS1A ~1.1 acres

PUBGh - Palustrine, Unconsolidated Bottom, Intermittently Exposed, Diked/Impounded.  
PEMC - Palustrine, Emergent, Seasonally Flooded.  
PFO1C - Palustrine, Forested, Broad-Leaved Deciduous, Seasonally Flooded.  
PSS1A - Palustrine, Scrub-Shrub, Broad-Leaved Deciduous, Temporarily Flooded.

### **Corridor Conflicts Identified Through OPP's Interagency Correspondence**

The following agencies identified potential conflicts with the route in response to OPP correspondence.

#### **Federal Emergency Management Agency (FEMA)**

FEMA identified that Des Moines and Louisa counties participate in the National Flood Insurance Program. As participants in this program, the Iowa DOT must obtain permits before building in a delineated flood plain.

#### **Des Moines County Engineer**

The Des Moines County engineer identified two potential hazardous waste sites. One is an abandoned gas station and the other is an abandoned road house which may have sold gasoline. The locations were circled on an enclosed paper map.

#### **Iowa DNR**

The Iowa DNR identified that the project may intersect habitats which contain protected species or rare natural communities. They made recommendations to minimize disturbance to these habitats.

#### **U.S. Army Corps of Engineers**

The U.S. Army Corps of Engineers stated that wetlands should be avoided. Any wetlands that will be filled or dredged will need to be mitigated. Also, floodplain issues will need to be assessed when more detailed plans are available.

#### **U.S. Fish and Wildlife Service**

The U.S. Fish and Wildlife Service identified federal endangered and threatened species that may reside in the project area. They included descriptions of likely habitats.

### **Comparison of GIS and Traditional Methods**

The traditional research method of interagency correspondence has several benefits which GIS cannot match. The correspondence with local authorities revealed two possible unregistered underground storage tanks. This reveals that GIS cannot replace a local pool of knowledge. Interagency correspondence also gives planners and engineers the assurance that other agencies give their approval of the project.

GIS has benefits which traditional methods cannot match. It produces quantifiable results, letting the user know specific conflicts. Feedback is relatively fast, so some problems are discovered quicker. GIS will not replace the traditional methods of interagency correspondence, but serves as an enhancement to it.

### **CONCLUSION**

GIS coverages downloaded from the WWW are useful to Iowa DOT's OPP. They allow for the sharing of geospatial data between agencies. GIS allows for the spatial analysis of these datasets. When used to analyze a specific route alignment, GIS can identify objects located near the project. This identification does not replace the interaction with other agencies currently taking place in the OPP, but serves to enhance it.